Radiological Health Data and Reports

VOLUME 9, NUMBER 7
JULY 1968
(Page 337-386)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^3	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 7, July 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

Page

REPORTS

Tritium in Surface Waters of the United States, 1966 ---- 337
A. A. Moghissi and *C. R. Porter*

Tritiated Moisture in the Atmosphere surrounding a Nuclear Fuel Reprocessing Plant ---------- 341
J. C. Daly, A. V. Manchester, J. J. Gabay, and *N. I. Sax*

DATA

SECTION I. MILK AND FOOD ---------- 347

National and International Milk Surveillance ---------- 348

1. Pasteurized Milk Network, March 1968, *PHS* ------ 348
2. Canadian Milk Network, March 1968 ---------- 351
3. Pan American Milk Sampling Program, March 1968, *PAHO* and *PHS* ---------- 352

State Milk Surveillance Activities ---------- 353

1. Colorado Milk Network, January–March 1968 ------ 354
2. Florida Milk Network, January–March 1968 ------- 355
3. Tennessee Milk Network, January–March 1968 ---- 356
4. Texas Milk Network, January–March 1968 -------- 357

CONTENTS—continued

Page

Food and Diet Surveillance ---- 359

1. Radionuclides in Institutional Diet Samples, October–December and Annual Summary 1967, *PHS* ---- 359

SECTION II. WATER ---- 365

Gross Radioactivity in Surface Waters of the United States, January 1968, *FWPCA* ---- 366

Radioactivity in Florida Waters, 1965 and 1966 ---- 368

SECTION III. AIR AND DEPOSITION ---- 371

Radioactivity in Airborne Particulates and Precipitation ---- 371

1. Radiation Alert Network, March 1968, *PHS* ---- 372

2. Canadian Air and Precipitation Monitoring Program, March 1968 ---- 375

3. Mexican Air Monitoring Program, March 1968 ---- 376

4. Pan American Air Sampling Program, March 1968, *PAHO* and *PHS* ---- 377

SECTION IV. OTHER DATA ---- 379

Environmental Levels of Radioactivity at Atomic Energy Commission Installations ---- 379

1. Oak Ridge Area, January–June 1967 ---- 379

2. Portsmouth Area Gaseous Diffusion Plant, July–December 1967 ---- 384

Reported Nuclear Detonations, June 1968 ---- 385

Synopses ---- iii

Guide for Authors ---- Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Harold O. Wyckoff
Department of Defense

Milton W. Lammering
Department of the Interior

Dr. Ronald G. Menzel
Department of Agriculture

Reuben Pomerantz
Department of Commerce

Robert E. Simpson
Food & Drug Administration, DHEW

John A. Harris
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder

Assistant Managing Editor
Charles F. Coyle

Senior Technical Editor
Marvin Rosenstein

Technical Editors
Warren A. Brill
Kurt L. Feldmann

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Center for Radiological Health

Reports

Tritium in Surface Waters of the United States, 1966

A. A. Moghissi and *C. R. Porter*[1]

During 1964, a tritium sampling network was established by the Public Health Service to measure the levels and consequently to determine the public health significance of tritium in surface waters of the United States. The analytical procedures used are described. Data for the samples obtained are presented. A means for estimating the radiation dose resulting from tritium in the body is developed.

Tritium is a radionuclide possessing extraordinary properties. With a mass three times that of protium (the hydrogen isotope with the mass number one), tritium causes the highest known isotope effect. The low beta energy emission with a maximum of 18 keV requires special procedures for its detection and measurement. The public health significance of tritium arises from the fact that it can replace protium in the biological processes. Although the amount of tritium occurring in natural sources is small, the atmospheric testing of thermonuclear devices and the expanding nuclear industry have caused a considerable increase in the environmental levels of tritium.

During 1964, a Tritium Sampling Network was established by the Public Health Service to measure the levels, and consequently to determine the public health significance of tritium in surface waters of the United States. To obtain coverage of the major river basins, 10 stations were selected from the 131 existing water pollution surveillance sampling stations operated by the Federal Water Pollution Control Administration. Eight of these stations are located downstream from nuclear facilities and the other two stations serve to establish baseline levels. The results of the initial study were published previously (*1*). Beginning in 1966, samples have been obtained from the Savannah River near Beaufort, S. C., and Augusta, Ga.; and the Broad River near Columbia, S. C. These three stations are part of the environmental surveillance program of the South Carolina State Board of Health, and include two stations located in the vicinity of the Savannah River Plant operated by E. I. du Pont de Nemours and Company for the Atomic Energy Commission. The locations of the sampling stations are given in table 1.

Analytical procedures

Composites of weekly grab samples (1 liter) of each calendar month are shipped in disposable containers for the Southeastern Radiological Health Laboratory for analysis. The samples are distilled, and 5-ml aliquots are taken for counting. Duplicate aliquots are mixed with 20 ml each of a scintillation solution of 7 grams 2,5-diphenyloxazole (PPO), 1.5 grams p-bis-(o-methystyryl)-benzene (bis-MSB), and 120 grams naphthalene per liter of dioxane. All operations involving the scintillation solution are carried out under red light. A Beckman

[1] Dr. Moghissi is chief, Physical Sciences and Mr. Porter is chief, Analytical Services, Southeastern Radiological Health Laboratory; Montgomery, Ala.

Table 1. Tritium concentration of surface waters in the United States, 1966[a]

Collection site	Concentration (nCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Big Sioux River:												
Sioux Falls, S. D.	<2.0	<2.0	4.9±0.5	<4.1	[b]	[b]	[b]	2.3±0.6	1.8±0.6	2.2±0.3	1.3±0.3	1.2±0.3
Clinch River:												
Kingston, Tenn.	8.0±1.8	<2.0	22.2±0.7	<4.1	5.4±4.1	[b]	2.6±0.6	2.3±0.6	1.2±0.6	3.4±0.4	2.9±0.3	2.9±0.3
Colorado River:												
Boulder City, Nev.	5.9±2.0	<2.0	7.9±0.4	<4.1	<4.1	[b]	4.2±0.5	4.3±0.5	3.3±0.6	4.2±0.4	3.5±0.4	3.1±0.3
Columbia River:												
Northport, Wash.	<2.0	<2.0	4.2±0.5	<4.1	<4.1	[b]	3.7±0.6	2.1±0.6	2.4±0.6	3.5±0.4	2.9±0.3	1.9±0.3
Pasco, Wash.	<2.0	2.1±2.0	6.8±0.6	<4.1	5.3±4.1	[b]	2.8±0.7	3.4±0.5	2.3±0.6	3.1±0.4	2.6±0.3	2.1±0.3
Hudson River:												
Poughkeepsie, N. Y.	<2.0	2.5±2.0	5.1±0.5	<4.1	<4.1	[b]	2.9±0.7	2.8±0.7	2.0±0.6	2.9±0.3	1.7±0.3	1.4±0.3
Mississippi River:												
New Orleans, La.	<2.0	<2.0	2.4±0.6	<4.1	<4.1	[b]	2.4±0.6	3.2±0.6	1.5±0.6	2.6±0.3	1.7±0.3	1.4±0.3
Ohio River:												
Toronto, Ohio	2.2±2.0	[b]	[b]	<4.1	[b]	[b]	2.9±0.7	[b]	1.9±0.6	3.2±0.4	[b]	[b]
Rio Grande:												
El Paso, Tex.	<2.0	<2.0	4.0±0.5	<4.1	<4.1	[b]	2.8±0.7	3.5±0.7	1.3±0.6	1.9±0.3	0.7±0.3	[b]
Savannah River:												
Port Wentworth, Ga.	32.0±2.1	10.9±1.7	6.2±0.5	13.8±4.1	5.2±4.1	[b]	14.9±0.7	8.5±0.5	12.8±0.4	7.3±0.3	8.6±0.4	9.6±0.4
Beaufort, S. C.	5.4±1.6	[b]	[b]	[b]	[b]	8.6±0.4	8.8±0.6	9.0±0.6	[b]	13.0±0.4	8.1±0.4	12.5±0.5
Augusta, Ga.	<2.0	[b]	[b]	[b]	[b]	2.2±0.6	8.8±0.6	9.0±0.6	[b]	13.0±0.4	8.1±0.4	12.5±0.5
Broad River:												
Columbia, S. C.	<2.0	[b]	[b]	[b]	[b]	1.4±0.6	1.8±0.6	1.5±0.6	[b]	1.3±0.6	2.6±0.3	1.4±0.3

[a] Minimum limits of detectability were:
January–February, 2 nCi/liter
March, June–December, 0.6 to 0.2 nCi/liter (see text)
April–May, 4.1 nCi/liter
[b] No sample received.

liquid scintillation counting system is used. A background sample is counted with each of the duplicates and a standard is counted between the duplicates. The counting time is 100 minutes. Details of the procedure are given by Moghissi, et al (*2*).

January and February samples were analyzed by procedures described previously (*1*), with a minimum limit of detectability of 2 nCi/liter. March and June–December 1966 samples were analyzed according to the procedures described above. Improvements in sample preparation during this time decreased the minimum limit of detectability from 0.6 to 0.2 nCi/liter. April and May samples were analyzed by the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio, with a minimum limit of detectability of 4.1 nCi/liter.

Results

Data for the samples collected during 1966 are presented in table 1. The values are associated with the stated counting errors at 2 σ confidence level. As expected, there is a large variation in the tritium concentrations of the surface waters; the largest variation is found in rivers near large nuclear installations. Because of differences in methods utilized throughout the year, no attempt was made to determine an average concentration.

Radiation dose to the population

The radiation dose resulting from tritium in the body can be estimated by using the relationship between the body burden q (in μCi) and R (in rem/week) recommended by the International Commission for Radiological Protection (ICRP) (*3*):

$$q = \frac{2.8 \times 10^{-3}\ m \bullet R}{f_{2\epsilon}} \qquad (1)$$

where m is the mass of the organ of reference (in this case, m = 70 kg, the mass of the total body), f_2 is the fraction of the body burden in the organ of reference (equal to 1 for tritium), and ϵ is the effective absorbed energy per disintegration of the radionuclide (equal to 0.01 MeV for tritium). Although Shtukkenberg (*4*) proposed an RBE factor (*6*) of 3 for beta emitters with the maximum energy of less than 60 keV, experiments with tritiated thymidine (*5*) have introduced more uncertainties regarding the RBE factor for tritium. A value of 1.7 (*3*) has been used for the present calculations, in accordance with recommendations of ICRP.

If R is expressed in millirem/year, then equation (1) becomes

$$R = 2.65\ q \qquad (2)$$

The hydrogen content of the standard man is 7,000 grams (*3*), which if oxidized would result in 63 liters of water. Assuming an even distribution of tritium in the body, and following the recommendations of the International Commission on Radiological Units and Measurements, (ICRM) (*6*), replacing R by DE [Dose Equivalent] equation (2) results in the following relationship:

$$DE\ (mrem/yr) = 0.17\ C\ (nCi/liter) \qquad (3)$$

where C represents the tritium concentration in the body in nCi/liter of water.

In estimating radiation dose to the public based on observed tritium concentrations in surface water, it is assumed that the concentration of tritium in all water taken into the body is equal to that found in surface water, and that the specific activity of tritium in the body is essentially the same as that in the surface water. Furthermore, it is assumed that a change in the concentration of tritium in the water will produce a corresponding body change in a relatively short period of time. The latter assumption is justified by the short (around 12 days) biological half-life of tritium (*3*).

Based on the range of concentrations of tritium in surface waters, the expected average values for C are between 2 and 15 nCi/liter, which correspond to a whole-body dose to the general population of between 0.3 and 2.5 millirem/year. In terms of Federal Radiation Council guidance, this represents 0.2 to 1.5 percent of the Radiation Protection Guide (170 mrem/year) for an average dose to a suitable sample of the population (*7*).

It is of particular interest to estimate the contribution of tritium from a major nuclear installation to the radiation exposure of the public. For example, it may be seen that the increase in tritium concentration in the Savannah River between Augusta, Ga., and Beaufort, S. C., following the discharge from the Savannah River Plant is in the range of 6 to 10 nCi/liter. Inasmuch as Beaufort receives its drinking water primarily from the Savannah River, this tritium concentration corresponds to an estimated whole-body dose of 1.0 to 1.7 mrem/year, or in terms of Federal Radiation Council guidance, 0.6 to 1.0 percent of the Radiation Protection Guide for an average dose to a suitable sample of the population (*7*).

It should be emphasized that the above calculated doses apply only to the areas sampled and cannot necessarily be extrapolated to other locations.

Acknowledgment

The authors wish to express their appreciation for the technical assistance of Mrs. Mae W. Williams and Miss Rachael H. Gorrie in performing the laboratory experiments, and Mrs. Ann B. Strong in the preparation of this paper.

Mention of commercial products used in connection with work reported in this article does not constitute an endorsement by the Public Health Service, and the Department of Health, Education, and Welfare.

REFERENCES

(*1*) CHESNUTT, M. W., J. C. DROBINSKI, JR. and R. H. GORRIE. Tritium in surface waters, 1964–1965. Radiol Health Data Rep 7:377–380 (1966).
(*2*) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low level counting by liquid scintillation. (To be published.)
(*3*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection. Report of Committee II on Permissible Dose for Internal Radiation (1959).
(*4*) YU. M. SHTUKKENBERG. Application of Tritium in Biological Research, A/AC. 82/G/L, 552 (1960). Nucl Sci Abstr 15:15342 (1961).
(*5*) DEWEY, W. C., R. M. HUMPHREY, and B. A. JONES. Comparison of tritiated thymidine, tritiated water, and cobalt-60 gamma rays in inducing chromosomal aberrations. Radiation Res 24:214 (February 1965).
(*6*) INTERNATIONAL COMMISSION OF RADIOLOGICAL UNITS AND MEASUREMENTS. Recommendations of the International Commission of Radiological Units and Measurements, National Bureau of Standards Handbook 85.
(*7*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (May 13, 1960).

Tritiated Moisture in the Atmosphere Surrounding a Nuclear Fuel Reprocessing Plant[1]

J. C. Daly, A. V. Manchester, J. J. Gabay and *N. I. Sax*[2]

A new wide-area sampling technique was used to collect more than 700 tritiated moisture samples over a 2-month period from seven sampling legs radiating out from a nuclear fuel reprocessing plant. For the 28 sampling periods studied, the average tritium radioactivity on the sampling leg northwest of the plant exceeded 2,500 pCi/liter, 75 percent of the time and exceeded 10,000 pCi/liter, 39 percent of the time as opposed to ambient levels of <2,500 pCi/liter. The highest tritium level recorded was 26,400 pCi/liter. These data are reported not so much for their epidemiologic value as for their value to public health agencies contempating radiological surveillance around nuclear facilities.

The nuclear fuel reprocessing plant, Nuclear Fuel Services, Inc. (NFS), located in western New York State, about 30 miles south of Buffalo, has been operational for approximately 2 years. One of the radionuclides it releases into the environment is tritium. It has been estimated that about 200 curies of tritium per day will be released during the reprocessing of spent fuel elements (*1*). Of this, 25 percent is released via the stack, 65 percent via liquid discharge into Buttermilk Creek and the remaining 10 percent goes to waste storage.

In order to determine the dispersion pattern and to relate the amount of tritium discharged to levels of tritium in atmospheric moisture, an intensive study of the area surrounding the plant was undertaken during the summer of 1967. A secondary goal was the evaluation of a new sampling technique for tritiated moisture.

[1] Supported by U. S. Public Health Service Grant No. RH–00412–03, National Center for Radiological Health.

[2] Mr. Daly is a senior chemist with the Radiological Sciences Laboratory, New York State Health Department; Mr. Manchester is a field research scientist with Health Research, Inc., New York State Health Department; Mr. Gabay is senior research scientist, and Mr. Sax, associate research scientist, both with Radiological Sciences Laboratory, Division of Laboratories and Research, New York State Health Department, Albany, N.Y. 12206.

Relatively little information is available concerning the levels of tritium released into the atmosphere by nuclear facilities. Most atmospheric surveillance programs encompass only gross beta measurements (*2-4*). Schmidt (*5*) fails to mention it as a constituent of the effluent. Monitoring of the atmosphere for tritium is briefly mentioned in Monsanto Research Corporation's environmental monitoring reports (*6-7*), but these reports state only that tritium levels were below the limit of detection.

Sampling method

The device used to collect tritiated moisture samples has been previously described in detail (*8*). Briefly, it consists of 200 g of silica gel in a plastic-screen bag. The unit is placed in a mason jar, sealed and shipped to the field where the silica gel bag is removed, suspended from a convenient overhang and allowed to extract moisture from the air. At the end of the sampling period it is replaced in the mason jar, which is sealed, and returned to the laboratory for tritium analysis.

Sampling legs (figure 1) were established which radiated from the plant with the stack as origin. The sampling points on each sam-

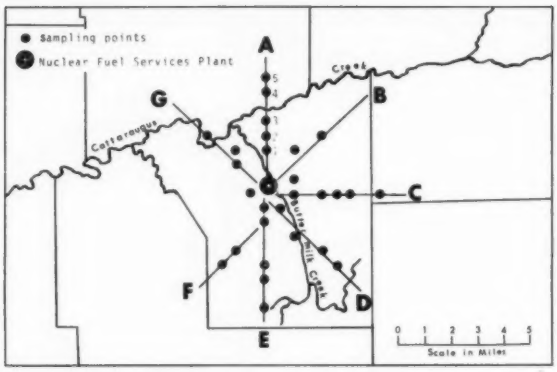

Figure 1. Sampling points for tritiated moisture surrounding NFS site

pling leg were numerically identified with the lowest numerical value assigned to the point closest to the plant as shown for leg A in figure 1. The sampling period was 48 hours of exposure of the silica gel sampler to the atmosphere. This method of sampling food affords two important advantages.

First, it allows large scale sampling with a minimum of difficulty. The only requirement is that the samplers must be distributed and then collected at the end of the sampling period. No power source, complicated equipment or measuring devices are necessary. The only limitation is the total distance involved in the placement and collection of the samples along the sampling network. The ability to do large scale sampling is a marked advantage in the determination of a dispersion pattern.

A second advantage to this sampling technique is the elimination of many of the uncertainties usually associated with the measurement of such parameters as air flow rate and collection efficiency which are necessary to compute tritium concentration in terms of radioactivity per unit volume. To delineate a distribution pattern, it is only necessary to compare the tritium content of the water vapor at one sampling point to that at other sampling points. Consequently, we need not concern ourselves with any sampling parameters other than perhaps the sampling period which is of interest only because we want to compare measurements taken within a given time interval.

Analytical method

Liquid scintillation counting techniques as described by Butler (*9*) are used, with slight modification. The sample is not enriched. Samples are vacuum distilled and 3 ml of the distillate are mixed with 17 ml of scintillator. Standard and background samples are prepared in the same manner as by Butler except these samples are not distilled. Background samples consisting of 3 ml of low tritium content water (3 pCi/liter) mixed with 17 ml of scintillator are used.

A Beckman liquid scintillation counting system (model LS–200 B) was used at a counting efficiency for tritium of 28 percent. Background counting rates are about 13-14 cpm. Based on a counting efficiency of 28 percent, a background of 13.5 cpm, a counting time of 100 minutes for sample and 300 minutes for background, and a 3 ml sample, the sensitivity for the Beckman system is 500 pCi/liter ± 100 percent at the 95-percent confidence level. Figure 2 shows the relationship between counting error and specific activity of the sample. It

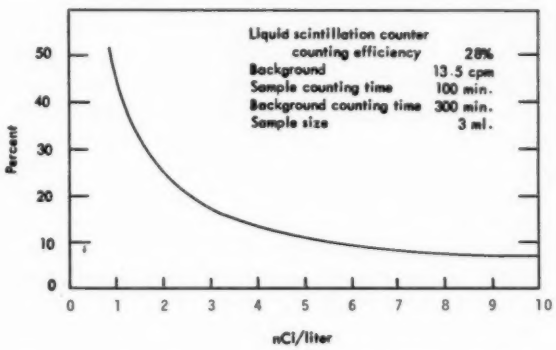

Figure 2. Counting error vs. level of tritium activity

should be noted that at tritium levels above 1,000 pCi/liter, the counting error is less than ± 50 percent. Above 5,000 pCi/liter, the counting error is reduced to 10 percent or less. The majority of water vapor samples analyzed were greater than 1,000 pCi/liter.

Discussion

Over 700 samples were collected on seven sampling legs during a 2-month period. The

Table 1. Tritium levels on sampling leg A (north of NFS)

Sampling dates	Concentration (nCi/liter)				
	Tritium levels at sampling points				
	A-1 (1.5)[a]	A-2 (2.0)	A-3 (2.5)	A-4 (3.3)	A-5 (4.0)
7/17-7/19	2.3	2.6	2.5	2.2	NS
7/19-7/21	3.2	2.1	2.4	2.4	NS
7/21-7/23	4.6	1.7	2.1	1.4	NS
7/23-7/25	2.0	.9	1.3	1.0	NS
7/25-7/27	2.0	3.3	2.6	2.3	1.8
7/27-7/29	3.2	6.6	2.6	2.2	2.1
7/29-7/31	9.6	2.7	1.4	NS	1.7
7/31-8/02	1.8	4.0	2.7	2.3	2.4
					NS
8/02-8/06	3.4	1.3	1.2	1.2	2.2
8/06-8/08	3.3	NS	1.9	2.3	1.5
8/08-8/10	1.8	1.2	1.5	NS	NS
8/10-8/12	1.9	1.9	1.3	1.8	NS
8/12-8/14	4.8	2.2	2.1	1.8	1.6
8/14-8/16	3.2	1.8	1.5	1.1	1.5
8/16-8/18	3.7	1.4	1.3	1.1	1.5
8/18-8/22	NS	1.7	1.2	1.5	2.4
8/22-8/26	1.8	1.4	1.1	1.2	1.4
8/26-8/30	3.2	1.9	2.4	1.8	1.7
8/30-9/05	18.6	6.4	4.0	4.6	4.5
9/05-9/07	5.3	1.3	1.8	1.9	2.9
9/07-9/09	2.3	.9	1.9	1.1	.6
9/09-9/11	3.6	1.7	.8	1.2	2.0
9/11-9/13	1.4	2.1	1.9	1.5	4.3
9/13-9/15	5.5	1.6	1.4	1.5	1.7
9/15-9/17	1.4	.5	.5	.7	NS
9/17-9/19	6.8	2.0	1.6	3.1	2.5
9/19-9/21	.7	.2	.5	.8	.6
9/21-9/23	1.8	1.7	.6	.6	1.0

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

study began in July 1967 and ran through the middle of September 1967. Tables 1 to 7 present the tritium radioactivity at each sampling point for all sampling legs for this 2-month span. Present ambient levels of tritium are about 200-1,000 pCi/liter for atmospheric moisture or precipitation (*10*), due to cosmic ray produced tritium and tritium resulting from nuclear weapons testing (*11*).

On this basis one can assume that tritium radioactivity in excess of these values can be attributed to tritium locally injected into the atmosphere in the area of the NFS site. It can readily be seen that the tritium radioactivity is generally higher in this area than in nonindustrial localities.

If one takes 2,500 pCi/liter as an arbitrary cutoff, analysis of the average tritium radioactivity (table 8) per sampling leg for all sampling periods yields the number of occurrences of radioactivity above this level for each sampling leg. In 21 cases out of 28, the tritium radioactivity in water vapor exceeds 2,500 pCi/liter on sampling leg G. Sampling legs A and E have a frequency of about 20 percent as com-

Table 2. Tritium levels on sampling leg B (northeast of NFS)

Sampling dates	Concentration (nCi/liter)		
	Tritium levels at sampling points		
	B-1 (1.3)[a]	B-2 (2.3)	B-3 (3.3)
7/17-7/19	3.7	2.1	2.0
7/19-7/21	1.9	NS	1.4
7/21-7/23	1.9	1.6	1.2
7/23-7/25	1.3	NS	1.9
7/25-7/27	1.6	NS	2.5
7/27-7/29	1.9	2.3	1.4
7/29-7/31	9.1	2.3	2.1
7/31-8/02	2.3	2.7	1.7
8/02-8/06	1.9	1.3	1.6
8/06-8/08	2.4	1.8	1.7
8/08-8/10	2.5	1.8	1.4
8/10-8/12	1.8	1.6	1.7
8/12-8/14	1.7	2.6	1.4
8/14-8/16	2.5	1.3	1.3
8/16-8/18	3.3	1.6	1.6
8/18-8/22	3.4	2.2	1.9
8/22-8/26	.8	.9	1.3
8/26-8/30	2.5	2.9	1.5
8/30-9/05	2.1	1.7	NS
9/05-9/07	1.6	2.2	1.6
9/07-9/09	1.6	1.3	.7
9/09-9/11	1.9	1.4	
9/11-9/13	1.6	1.7	1.4
9/13-9/15	NS	1.2	.8
9/15-9/17	1.1	1.0	.5
9/17-9/19	1.5	.9	1.0
9/19-9/21	.4	NS	.9
9/21-9/23	.8	NS	.8

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 3. Tritium levels on sampling leg V (east of NFS)

Sampling dates	Concentration (nCi/liter)				
	Tritium levels at sampling points				
	C–1 (1.3)[a]	C–2 (1.8)	C–3 (2.4)	C–4 (2.8)	C–5 (3.4)
7/17–7/19	2.0	2.2	1.9	1.4	NS
7/19–7/21	1.6	1.9	1.4	1.1	NS
7/21–7/23	2.0	1.6	1.4	1.3	NS
7/23–7/25	0.4	.6	0.3	1.1	NS
7/25–7/27	1.9	3.7	3.0	1.8	2.0
7/27–7/29	2.2	2.2	1.7	2.2	1.5
7/29–7/31	2.4	2.4	1.2	2.1	1.7
7/31–8/02	2.0	NS	2.0	2.6	2.2
8/02–8/06	2.1	2.4	1.6	1.4	1.5
8/06–8/08	1.7	1.5	1.8	1.6	1.7
8/08–8/10	2.7	2.8	1.8	1.4	1.3
8/10–8/12	2.3	1.7	1.2	1.7	1.8
8/12–8/14	1.4	1.7	1.4	1.4	1.1
8/14–8/16	1.7	2.0	1.6	1.3	1.7
8/16–8/18	1.0	1.0	1.0	1.1	1.0
8/18–8/22	1.5	1.1	1.3	1.6	1.3
8/22–8/26	1.3	1.8	.7	1.0	.8
8/26–8/30	2.1	NS	1.3	1.1	1.3
8/30–9/05	2.3	2.0	2.0	1.7	1.6
9/05–9/07	1.7	1.7	1.3	1.7	1.9
9/07–9/09	1.0	1.0	1.2	1.2	1.0
9/09–9/11	1.8	1.0	1.4	1.8	1.1
9/11–9/13	1.6	.9	1.0	.8	1.5
9/13–9/15	0.9	1.2	.4	1.2	1.4
9/15–9/17	2.2	1.0	1.3	1.1	.7
9/17–9/19	1.7	.7	.8	.9	1.0
9/19–9/21	.5	1.0	NS	.5	.3
9/21–9/23	2.0	2.6	1.5	0.6	1.1

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 4. Tritium levels on sampling leg D (southeast of NFS)

Sampling dates	Concentration (nCi/liter)		
	Tritium levels at sampling points		
	D–2 (1.5)[a]	D–3 (2.7)	D–4 (3.4)
7/17–7/19	1.6	2.2	2.0
7/19–7/21	2.3	1.7	1.9
7/21–7/23	1.9	1.2	1.4
7/23–7/25	1.0	.8	1.1
7/25–7/27	1.6	1.3	1.8
7/27–7/29	2.1	NS	1.7
7/29–7/31	2.2	1.9	1.9
7/31–8/02	2.1	1.8	2.1
8/02–8/06	2.0	2.2	NS
8/06–8/08	1.4	1.2	1.9
8/08–8/10	3.4	2.1	2.0
8/10–8/12	4.1	2.1	2.1
8/12–8/14	1.9	1.9	1.7
8/14–8/16	1.6	1.3	2.2
8/16–8/18	1.3	1.6	1.4
8/18–8/22	1.4	1.2	1.0
8/22–8/26	1.4	.6	.8
8/26–8/30	1.5	1.3	2.1
8/30–9/05	2.6	2.9	1.9
9/05–9/07	2.5	2.1	1.3
9/07–9/09	1.6	.6	NS
9/09–9/11	1.2	1.1	1.3
9/11–9/13	1.6	1.6	1.3
9/13–9/15	1.8	1.9	1.3
9/15–9/17	.8	1.1	.4
9/17–9/19	2.2	NS	2.0
9/19–9/21	1.1	.8	.5
9/21–9/23	2.5	1.7	NS

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

pared to 75 percent for leg G. The lowest levels appeared along leg C, where average tritium level never exceeded 2,500 pCi/liter. The dispersion pattern of tritiated atmospheric moisture in the area is readily discernible.

Summary

It was demonstrated that the sampling technique was well suited to the type of study undertaken. Quantitative information on tritium levels in atmospheric moisture and dispersion patterns for tritiated atmospheric moisture were obtained for the fuel reprocessing site. It is recognized that much more of such work needs to be done. Further studies will attempt to determine the contributions of local sources of HTO, followed by correlation of meteorological data to dispersion patterns.

REFERENCES

(*1*) NUCLEAR FUELS SERVICES, INC. Safety Analysis, Part B of License Application, Section VII, Vol. I, Copy No. 109 (July 1962).

Table 5. Tritium levels on sampling leg E (south of NFS)

Sampling dates	Concentration (nCi/liter)				
	Tritium levels at sampling points				
	E-1 (0.5)[a]	E-2 (1.0)	E-3 (2.4)	E-4 (3.1)	E-5 (4.0)
7/17-7/19	NS	NS	NS	NS	NS
7/19-7/21	NS	NS	NS	NS	NS
7/21-7/23	NS	NS	NS	NS	NS
7/23-7/25	NS	NS	NS	NS	NS
7/25-7/27	1.7	1.4	1.8	1.8	1.7
7/27-7/29	1.6	1.5	1.7	1.4	0.7
7/29-7/31	1.9	1.9	1.5	1.4	1.0
7/31-8/02	2.2	1.5	1.8	2.0	1.6
8/02-8/06	9.6	6.4	1.9	1.6	1.7
8/06-8/08	2.2	2.2	1.3	1.2	2.1
8/08-8/10	0.2	1.7	1.0	1.2	1.2
8/10-8/12	10.0	6.0	2.5	2.2	1.6
8/12-8/14	17.0	6.7	1.4	1.4	1.6
8/14-8/16	2.0	1.5	1.3	NS	1.4
8/16-8/18	1.2	1.3		.9	1.1
8/18-8/22	1.5	1.2	1.8	1.1	1.3
8/22-8/26	2.8	2.3	1.0	1.1	1.3
8/26-8/30	1.0	1.1	NS	1.3	1.3
8/30-9/05	3.9	NS	1.5	1.7	1.4
9/05-9/07	3.3	NS	2.0	NS	NS
9/07-9/09	9.6	6.1	1.8	1.9	1.0
		NS			
9/09-9/11	5.8	2.5	1.7	1.1	1.3
9/11-9/13	2.9	1.7	1.2	0.9	1.2
9/13-9/15	NS	NS	.8	2.0	1.2
9/15-9/17	3.7	2.2	.9	0.4	0.7
9/17-9/19	2.4	1.8	1.8	1.1	1.6
9/19-9/21	.4	.0	.7	NS	1.1
9/21-9/23	.7	1.0	.9	1.3	1.2

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 6. Tritium levels on sampling leg F (southwest of NFS)

Sampling dates	Concentration (nCi/liter)	
	Tritium levels at sampling points	
	F-1 (2.3)[a]	F-2 (3.0)
7/17-7/19	1.2	1.3
7/19-7/21	0.9	1.1
7/21-7/23	1.3	2.2
7/23-7/25	.9	.8
7/25-7/27	1.7	1.8
7/27-7/29	1.5	1.6
7/29-7/31	1.6	1.6
7/31-8/02	1.3	2.3
8/02-8/06	2.2	2.0
8/06-8/08	1.9	2.1
8/08-8/10	.9	.9
8/10-8/12	2.7	2.6
8/12-8/14	2.7	2.6
8/14-8/16	NS	1.3
8/16-8/18	1.3	1.1
8/18-8/22	.6	1.2
8/22-8/26	.4	1.1
8/26-8/30	.8	1.0
8/30-8/05	1.6	1.1
9/05-9/07	1.8	3.5
9/07-9/09	2.3	1.1
9/09-9/11	1.5	2.3
9/11-9/13	NS	2.1
9/13-9/15	1.6	1.9
9/15-9/17	1.0	.6
9/17-9/19	1.6	1.1
9/19-9/21	.3	.8
9/21-9/23	1.4	.5

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 7. Tritium levels on sampling leg G (northwest of NFS)

Sampling dates	Concentration (nCi/liter)			
	Tritium levels at sampling points			
	G-1 (0.5)[a]	G-2 (1.3)	G-3 (1.6)	G-4 (2.8)
7/17-7/19	1.9	13.8	8.2	3.4
7/19-7/21	7.2	11.7	7.8	3.7
7/21-7/23	5.5	4.8	5.7	1.8
7/23-7/25	.7	1.2	1.4	1.0
7/25-7/27	1.5	1.7	6.2	6.4
7/27-7/29	4.1	3.8	3.9	5.3
7/29-7/31	3.7	6.9	12.7	8.9
7/31-8/02	3.6	9.2	7.2	7.8
8/02-8/06	8.5	13.2	16.5	5.6
8/06-8/08	6.5	10.3	8.1	5.9
8/08-8/10	1.0	2.0	1.8	1.9
8/10-8/12	4.9	4.0	5.6	3.2
8/12-8/14	9.9	6.6	12.5	3.7
8/14-8/16	2.9	11.2	7.0	3.8
8/16-8/18	3.4	2.6	2.2	3.5
8/18-8/22	2.9	3.7	3.5	4.7
8/22-8/26	4.6	NS	5.4	4.3
8/26-8/30	3.2	10.5	5.2	2.6
8/30-9/05	5.4	2.8	2.6	8.6
9/05-9/07	5.7	3.0	3.6	4.3
9/07-9/09	1.2	1.4	.9	1.4
9/09-9/11	13.0	9.9	7.3	3.5
9/11-9/13	6.4	7.5	15.9	4.5
9/13-9/15	4.9	12.4	26.4	12.9
9/15-9/17	3.2	4.5	3.2	1.5
9/17-9/19	2.8	1.8	3.7	3.1
9/19-9/21	.7	.9	NS	.8
9/21-9/23	.8	.7	1.1	1.2

[a] Figures in parentheses indicate the number of miles from NFS.
NS, no sample collected.

Table 8. Average tritium radioactivity for each sampling leg (concentration, nCi/liter)

Sampling dates	Sampling leg and direction from NFS						
	A	B	C	D	E	F	G
	(North)	(Northeast)	(East)	(Southeast)	(South)	(Southwest)	(Northwest)
7/17–7/19	2.4	2.6	1.9	2.0	NS	1.2	6.8
7/19–7/21	2.5	1.6	1.5	2.0	NS	1.0	7.6
7/21–7/23	2.4	1.6	1.6	1.5	NS	1.7	4.4
7/23–7/25	1.3	1.6	.6	1.0	NS	.9	1.1
7/25–7/27	2.4	2.1	2.5	1.6	1.7	1.7	4.0
7/27–7/29	3.3	1.9	2.0	1.9	1.4	1.5	4.3
7/29–7/31	3.8	4.5	2.0	2.0	1.5	1.6	8.0
7/31–8/02	2.6	2.2	2.2	2.0	1.8	1.8	7.0
8/02–8/06	1.8	1.6	1.8	2.1	4.2	2.1	10.9
8/06–8/08	2.3	2.0	1.6	1.5	1.8	2.0	7.7
8/08–8/10	1.5	1.9	2.0	2.5	1.1	.9	1.7
8/10–8/12	1.7	1.7	1.7	2.8	4.5	2.6	4.4
8/12–8/14	2.5	1.9	1.4	1.8	5.6	2.6	8.2
8/14–8/16	1.8	1.7	1.6	1.7	1.6	1.3	6.2
8/16–8/18	1.8	2.2	1.0	1.5	1.1	1.2	2.9
8/18–8/22	1.7	2.5	1.4	1.2	1.4	.9	3.7
8/22–8/26	1.4	1.0	1.1	.9	1.7	.8	4.8
8/26–8/30	2.2	2.3	1.4	1.4	1.2	.9	5.4
8/30–9/05	7.6	1.9	1.9	2.5	2.1	1.4	4.9
9/05–9/07	2.7	1.8	1.7	2.2	2.7	2.7	4.2
9/07–9/09	1.3	1.2	1.1	1.2	4.1	1.7	1.2
9/09–9/11	1.9	1.6	1.4	1.2	2.5	1.9	8.4
9/11–9/13	2.2	1.5	1.2	1.5	1.6	1.6	8.6
9/13–9/15	2.3	1.0	1.0	1.7	1.3	1.7	14.1
9/15–9/17	.8	.8	1.2	.8	1.6	.8	3.1
9/17–9/19	3.2	1.1	1.0	2.1	1.8	1.4	2.8
9/19–9/21	.6	.7	.5	.8	.6	.5	.6
9/21–9/23	1.1	.8	1.6	2.1	1.0	1.0	.9

NS, no sample collected.

(*2*) MORGAN, K. Z., W. S. SNYDER, and D. M. DAVIS. Health physics and safety annual report for 1965, ORNL–3969.

(*3*) ESSIG, T. H. and J. K. SOLDAT. Evaluation of radiological conditions in the vicinity of Hanford, January–June 1966, BNWL–391 (March 1967).

(*4*) WILSON, R. H. Evaluation of radiological conditions in the vicinity of Hanford for 1964. BNWL–90 (July 1965).

(*5*) SCHMIDT, W. C. Treatment of gaseous effluents, HW–49549A (April 10, 1957).

(*6*) ADAMS, P. C. and H. E. MEYER. Environmental monitoring report, January–June 1965, MLM–1275.

(*7*) ANDERSON, H. F. and W. E. SHEEHAN. Environmental monitoring report, July–December 1966 and summary 1966, MLM–1391.

(*8*) SAX, N. I. and J. J. GABAY. A Surveillance Technique for Tritiated Moisture in the Atmosphere. Proceedings of Symposium on Environmental Surveillance in the Vicinity of Nuclear Facilities, Augusta, Ga. (January 24–26, 1968) in press.

(*9*) BUTLER, F. E. Determination of tritium in water and urine. Anal Chem 33:409–414 (1961).

(*10*) DINGLE, A. N. and D. GATZ. Rain scavenging studies. Progress Report No. 3 (UC–53–4) Department of Meteorology and Oceanography, Michigan University, Ann Arbor, Mich. (May 1967) 46 pgs.

(*11*) BUTTLAR, H. V. Tritium in Rainwater. Earth Science and Meteoritics, J. Geiss and E. D. Goldberg, Editors. North Holland Publishing Company, Amsterdam (1963) pp. 188-206.

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained by radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (May 13, 1960).
(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 (September 1960).
(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).
(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1966	September 1967

1. Pasteurized Milk Network
March 1968

National Center for Radiological Health
and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, Washington, D.C., the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*); the February 1968 issue (*2*) introduced several changes in the interpretation and reporting of data.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥50	10
Strontium-90	<20	2	≥20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for March 1968 and the 12-month period, April 1967–March 1968[a]

Sampling location		Radionuclide concentration (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Apr 1967–Mar 1968	March 1968	Apr 1967–Mar 1968	March 1968	Apr 1967–Mar 1968	March 1968	Apr 1967–Mar 1968	March 1968	Apr 1967–Mar 1968	March 1968
Ala:	Montgomery	0	0	10	11	0	0	14	15	0	0
Alaska:	Palmer	1	0	6	5	0	0	18	13	1	0
Ariz:	Phoenix	0	0	2	2	0	0	2	6	0	0
Ark:	Little Rock	0	0	22	19	0	0	19	18	0	0
Calif:	Sacramento	2	0	3	6	0	0	6	11	1	3
	San Francisco	2	3	3	4	0	0	4	5	1	0
C. Z:	Cristobal	0	0	3	0	0	0	16	5	0	0
Colo:	Denver	1	0	6	4	1	0	6	0	0	0
Conn:	Hartford	NA	NA	9	7	0	0	16	10	0	0
Del:	Wilmington	NA	NA	11	9	0	0	10	1	0	0
D. C:	Washington	0	0	10	9	0	0	7	6	0	0
Fla:	Tampa	0	0	8	9	0	0	72	57	0	0
Ga:	Atlanta	0	0	15	12	0	0	22	22	0	0
Hawaii:	Honolulu	0	0	3	3	1	0	6	0	0	0
Idaho:	Idaho Falls	1	0	6	4	0	0	8	8	0	0
Ill:	Chicago	0	0	9	7	0	0	12	5	0	0
Ind:	Indianapolis	NA	NA	8	7	0	0	8	4	0	0
Iowa:	Des Moines	1	0	7	6	0	0	8	8	0	2
Kans:	Wichita	2	3	8	6	0	0	4	0	0	0
Ky:	Louisville	0	0	12	12	0	0	6	6	0	0
La:	New Orleans	0	0	23	21	0	0	25	23	0	0
Maine:	Portland	NA	NA	11	8	0	0	32	24	0	0
Md:	Baltimore	0	0	10	7	0	0	8	4	0	0
Mass:	Boston	0	0	11	10	0	0	27	21	0	0
Mich:	Detroit	NA	NA	9	9	0	0	13	13	0	0
	Grand Rapids	NA	NA	10	8	0	0	17	18	0	0
Minn:	Minneapolis	1	0	12	8	0	0	14	10	0	2
Miss:	Jackson	0	0	18	18	0	0	15	13	0	0
Mo:	Kansas City	2	0	8	8	0	0	4	7	1	2
	St. Louis	2	2	10	8	0	0	7	6	0	0
Mont:	Helena	1	0	6	6	0	0	8	5	0	3
Nebr:	Omaha	1	0	8	8	0	0	6	5	0	0
Nev:	Las Vegas	0	0	2	3	0	0	4	11	0	0
N. H:	Manchester	NA	NA	13	11	0	0	39	24	0	0
N. J:	Trenton	NA	NA	9	8	0	0	11	6	0	0
N. Mex:	Albuquerque	0	0	2	2	0	0	2	5	0	0
N. Y:	Buffalo	NA	NA	8	7	0	0	12	9	0	0
	New York City	NA	NA	10	7	0	0	14	15	0	0
	Syracuse [b]	NA	NA	7	6	0	0	11	8	0	0
N. C:	Charlotte	0	0	16	14	1	0	14	13	0	0
N. Dak:	Minot	3	3	12	10	0	0	13	10	0	0
Ohio:	Cincinnati	NA	NA	9	9	0	0	7	10	0	0
	Cleveland	NA	NA	9	7	0	0	11	3	0	0
Okla:	Oklahoma City	0	0	10	10	0	0	5	3	0	0
Ore:	Portland	2	0	7	6	1	0	15	14	0	0
Pa:	Philadelphia	NA	NA	9	8	0	0	9	5	0	0
	Pittsburg	NA	NA	12	9	0	0	16	11	0	0
P. R:	San Juan	0	0	5	4	0	0	13	14	0	0
R. I:	Providence	NA	NA	10	7	0	0	21	16	0	0
S. C:	Charleston	0	0	15	13	0	0	30	23	0	0
S. Dak:	Rapid City	2	3	11	6	0	0	11	8	0	0
Tenn:	Chattanooga	0	0	15	13	0	0	14	11	0	0
	Memphis	0	0	12	10	0	0	5	9	0	0
Tex:	Austin	0	0	4	4	0	0	4	7	0	0
	Dallas	0	0	8	8	0	0	6	9	0	0
Utah:	Salt Lake City	1	1	5	4	0	0	12	12	0	0
Va:	Norfolk	0	0	10	11	0	0	14	8	0	0
Vt:	Burlington	NA	NA	12	8	0	0	11	12	0	0
Wash:	Seattle	2	3	10	7	0	0	26	19	1	5
	Spokane	1	0	9	0	0	0	15	18	0	0
W. Va:	Charleston	0	0	11	8	0	0	6	4	0	0
Wisc:	Milwaukee	NA	NA	8	6	0	0	13	9	0	0
Wyo:	Laramie	0	0	5	4	0	0	6	10	0	0
Network monthly average		0	0	9	8	0	0	13	10	0	0

[a] See text for averaging procedure.
[b] 12-month averages represent only 9 months data.
NA, no analysis.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains averages

for March 1968 and 12-month averages for the period April 1967 through March 1968. The 12-month average enables evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes "averaged over periods of the order of a year," as an appropriate criterion (*3*). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (*2*). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample, but any positive value reflects at least one weekly sample which was above the minimum detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium-90, 2; cesium–137, barium–140, and iodine–131, 10.

The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

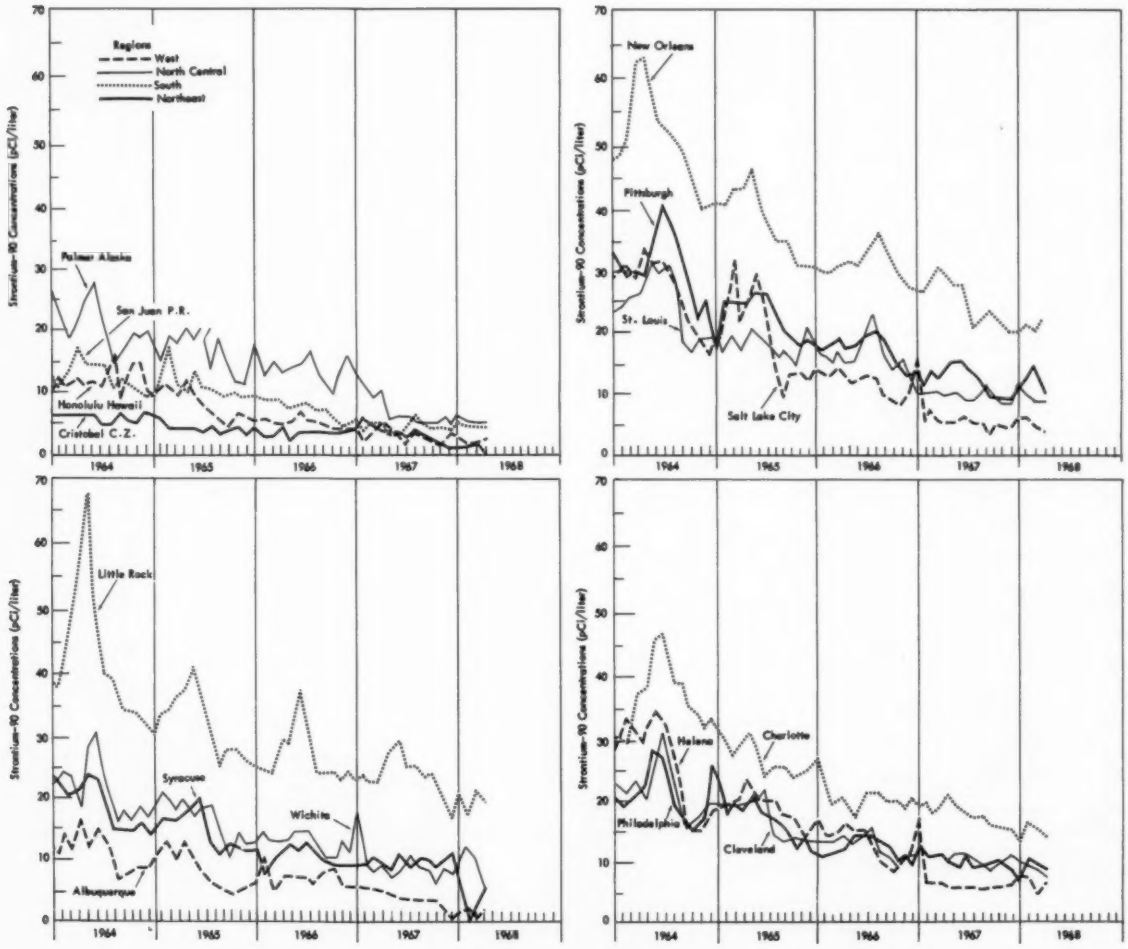

Figure 2. Strontium–90 concentrations in pasteurized milk, 1964–March 1968

2. Canadian Milk Network [1] March 1968

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the April 1968 issue of *Radiological Health Data and Reports* (*4*).

The March 1968 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 3. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from April 1968 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Stable elements and radionuclides in Canadian whole milk, March 1968

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium -90 (pCi/liter)	Cesium -137 (pCi/liter)
Calgary	1.11	1.5	9	18
Edmonton	1.10	1.5	8	20
Ft. William	1.08	1.5	12	19
Fredericton	1.04	1.4	14	23
Halifax	1.12	1.5	15	19
Montreal	1.09	1.5	12	23
Ottawa	1.11	1.5	9	22
Quebec	1.07	1.5	13	26
Regina	1.10	1.5	7	15
St. John's, Nfld	1.10	1.5	18	40
Saskatoon	1.09	1.4	8	13
Saulte Ste. Marie	1.02	1.6	14	20
Toronto	1.12	1.6	6	13
Vancouver	1.11	1.5	14	49
Windsor	1.15	1.6	5	17
Winnipeg	1.14	1.6	8	30
Average	1.10	1.5	11	23

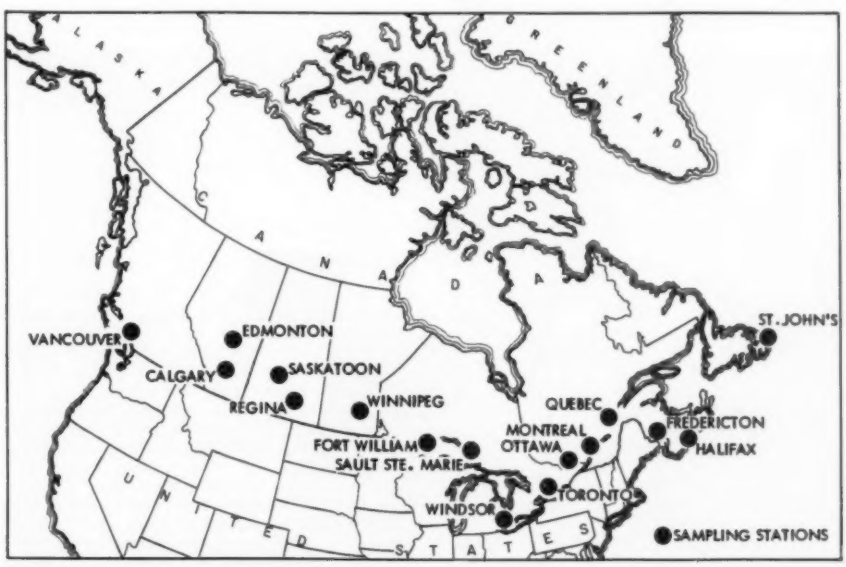

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program March 1968

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*5*).

Figure 4. Pan American Milk Sampling Program stations

Table 4 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for March 1968.

Table 4. Stable element and radionuclide concentration in Pan American milk,[a] March 1968

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 [b] (pCi/liter)	Cesium -137 [b] (pCi/liter)
Chile: Santiago	1	1.5	0	0
Colombia: Bogota	1	1.5	0	0
Ecuador: Guayaquil	1	1.6	0	0
Jamaica: Montego Bay	1	1.2	7	195
Canal Zone: Cristobal [c]	5	1.5	0	5
Puerto Rico: San Juan [c]	5	1.6	4	14

[a] All strontium-89 results were ≤5 pCi/liter; iodine-131 and barium-140 results were ≤10 pCi/liter.

[b] Strontium-90 single sample results ≤2 pCi/liter and cesium-137 results ≤10 pCi/liter are reported as 0.

[c] For comparison, the radionuclide concentrations in Pasteurized Milk Network samples collected at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 9:20–23 (January 1968).

(*2*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, October 1967. Radiol Health Data Rep 9:86–89 (February 1968).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*4*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*5*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and issue of appearance.

State milk network	Period reported	Last presented
California	October–December 1967	June 1968
Connecticut	October–December 1967	May 1968
Indiana	October–December 1967	May 1968
Iowa	October–December 1967	May 1968
Michigan	October–December 1967	May 1968
Minnesota	October–December 1967	May 1968
New York	October–December 1967	May 1968
Oregon	October–December 1967	June 1968
Pennsylvania	October–December 1967	May 1968
Washington	October–December 1967	June 1968

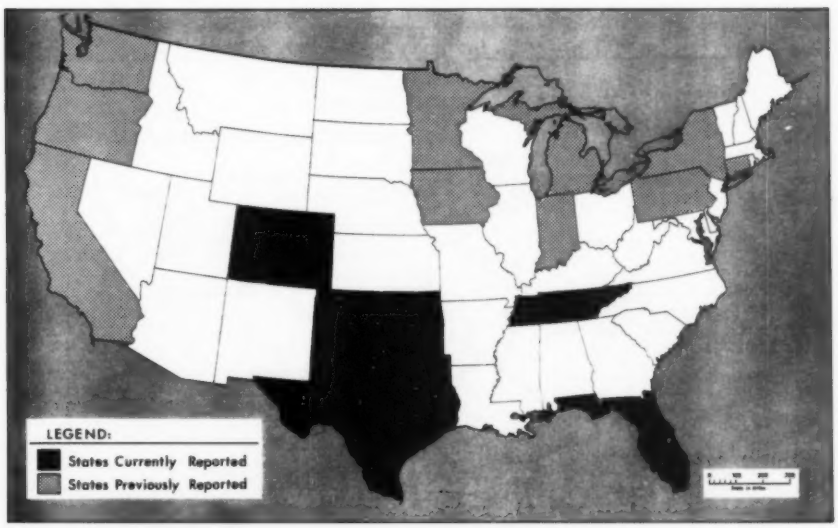

Figure 1. Reported State milk programs

1. Colorado Milk Network January–March 1968

Air, Occupational and Radiation Hygiene Division, Colorado State Department of Public Health

The Radiation Hygiene Section of the Colorado State Health Department initiated analysis of milk for gamma-ray emitting radionuclides in January 1962. Initially a composite milk sample from the major producers supplying the Denver area was collected by the Denver City and County Health Department for the State.

In August 1962, the State expanded this program to include the sampling of raw milk from the major milk producing areas supplying the entire State. The routine sampling rate was established by the Milk, Food and Drug Section of the State Health Department. Milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, barium-lanthanum–140, cesium–137 and potassium by gamma-ray spectrometry. Employed in this procedure is a 4- by 5-inch diameter NaI (Tl) crystal housed in a modified office safe lined with 2 inches of lead and a 512 multichannel pulse-height analyzer using a typewriter readout. Samples and backgrounds are counted for 40 minutes in a 2 quart (1,892 ml) Plexiglas Marinelli beaker. Calculation is by the matrix method (*1*) and minimum detectable concentrations (MDC, 3 σ) are: iodine–131, 15 pCi/liter; barium-lanthanum–140, 21 pCi/liter; cesium–137, 16 pCi/liter; and potassium, 0.25 g/liter.

Current summary

Five milk samples were collected and counted during the period from January 1, 1968, to March 31, 1968. (Sampling was curtailed during February and March.) Iodine–131, barium-lanthanum-140 and cesium–137 were below the respective MDC's in all samples. Potassium concentrations averaged 1.46 $\pm$ 0.3 (2 σ) g/liter.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	January 1968
October–December 1967	April 1968

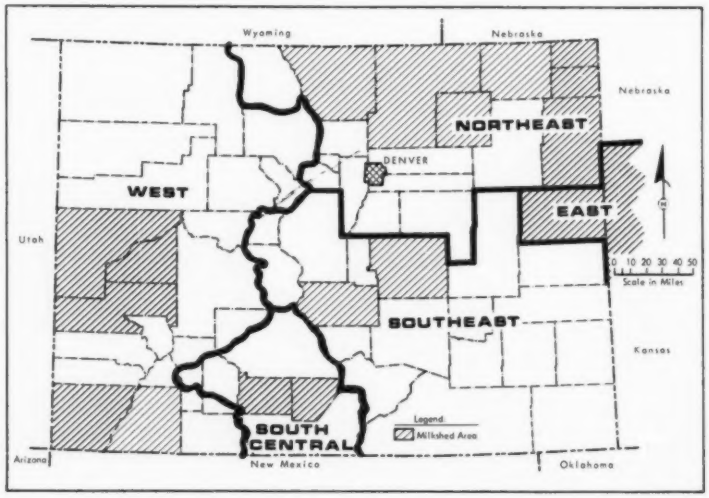

Figure 2. Colorado milk sampling stations

2. Florida Milk Network January–March 1968

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has been expanded to include the analysis of milk for strontium–89, strontium–90, cesium–137, barium–140 and potassium, in addition to iodine–131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique (*2*). Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter et al. (*3*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*4*).

Figure 3. Florida milk sampling areas

Radionuclide concentration levels for January through March 1968, are presented in table 1. Strontium–89 analyses have been discontinued since 1965 due to extremely low levels. Iodine–131 concentration for this period at all locations were below the minimum detectable level of 20 pCi/liter.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	January 1968
October–December 1967	April 1968

Table 1. Stable element and radionuclide concentrations in Florida raw milk January–March 1968

Sampling location	Concentration (g/liter)			Radionuclide concentration (pCi/liter)								
	Potassium			Strontium-90			Cesium-137			Barium-140		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
West	1.3	1.2	1.4	NA	26	13	24	25	ND	26	ND	ND
North	1.4	1.3	1.4	NA	15	16	ND	ND	ND	ND	ND	ND
Northeast	1.3	1.4	1.4	NA	NA	NA	65	46	65	ND	ND	ND
Central	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tampa Bay area	1.4	1.6	1.4	NA	NA	9	49	62	54	ND	ND	ND
Southeast	1.3	1.5	1.6	NA	9	9	58	65	106	ND	ND	21

NA, no analysis.
ND, nondetectable.
NS, no sample.

3. Tennessee Milk Network January–March 1968

Division of Preventable Diseases
Department of Public Health
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 4). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city are analyzed by gamma-ray scintillation spectrometry for potassium–40, iodine–131, cesium–137, and barium–140, using a 3.5 liter sample (*5*). After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calcium and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a crosscheck between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 2 for the period of January through March 1968. During this period, radionuclide concentrations were below the minimum detectable levels for strontium–89 (<5 pCi/liter), iodine–131 (<9 pCi/liter), and barium–140 (< pCi/liter).

Table 2. Radionuclides in Tennessee pasteurized milk January-March 1968

Location	Month 1968	Concentration (g/liter)	Radionuclide concentration (pCi/liter)	
		Potassium	Strontium -90	Cesium -137
Chattanooga	January	1.4	15	19
	February	1.5	14	19
	March	1.4	15	13
Clinton	January	1.3	8	17
	February	1.4	12	20
	March	1.5	10	17
Knoxville	January	1.4	12	14
	February	1.5	15	21
	March	1.5	12	20

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	January 1968
October–December 1967	April 1968

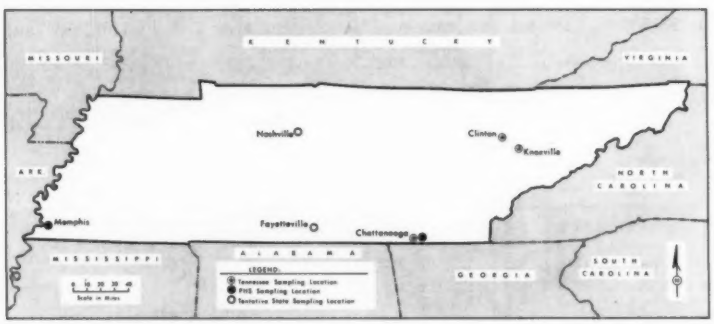

Figure 4. Tennessee pasteurized milk sampling stations

4. Texas Milk Network January–March 1968

Texas State Department of Health[2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, samples of raw milk are collected from each of twelve sampling points once each calendar quarter. The station locations shown in figure 5 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium–40, iodine–131, barium–140 and cesium–137 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium–40, strontium–90 and cesium–137 results by station and month for January through March 1968 are presented in table 3. During this time, the iodine–131, and barium–140 concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through March 1968 is presented in figure 6.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*7*).

[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

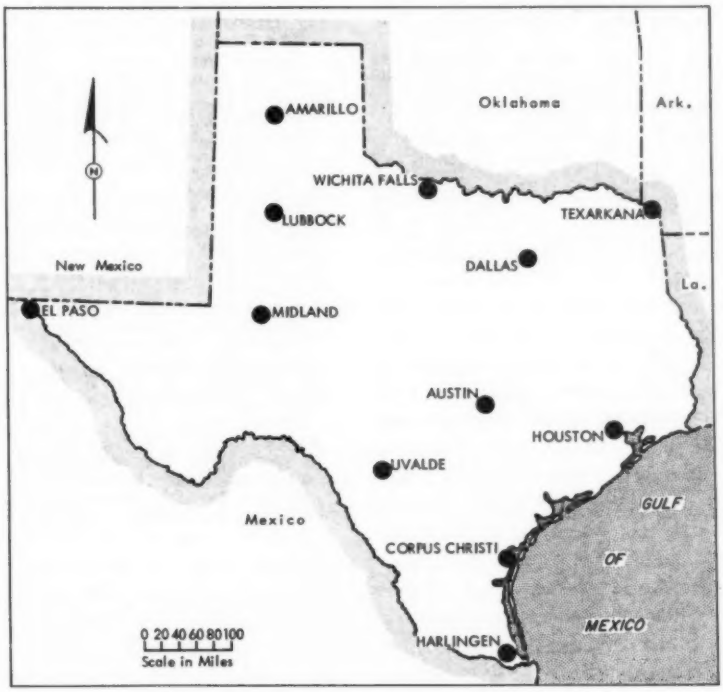

Figure 5. Texas milk sampling stations

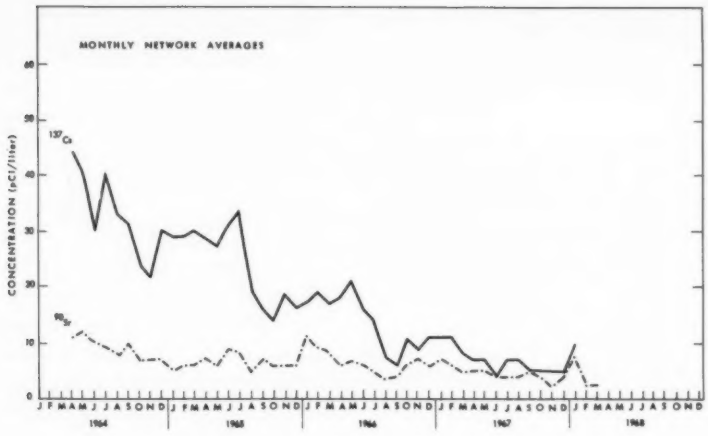
MONTHLY NETWORK AVERAGES
CONCENTRATION (pCi/liter)
137Cs
90Sr
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1964
1965
1966
1967
1968

Figure 6. Radionuclide concentrations in Texas milk April 1964–March 1968

Table 3. Stable element and radionuclide concentrations in Texas raw milk network, January–March 1968

Sampling location [a]	Concentration (g/liter)			Radionuclide concentration (pCi/liter)					
	Potassium			Strontium-90			Cesium-137		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
Amarillo	NS	NS	NS	NS	NS	NS	NS	NS	NS
Corpus Christi	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Paso	NS	1.5	NS	NS	2	NS	NS	ND	NS
Fort Worth	1.5	NS	NS	6	NS	NS	5	NS	NS
Harlingen	NS	NS	1.6	NS	NS	2	NS	NS	ND
Houston	1.5	NS	NS	8	NS	NS	15	NS	NS
Lubbock	NS	1.6	NS	NS	3	NS	NS	ND	NS
Midland	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Antonio	NS	NS	1.5	NS	NS	2	NS	NS	ND
Texarkana	NS	NS	NS	NS	NS	NS	NS	NS	NS
Uvlade	NS	NS	NS	NS	NS	NS	NS	NS	NS
Wichita Falls	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] Samples are collected quarterly from each sampling location on a staggered basis.
ND, nondetectable.
NS, no sample.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1967	January 1968
October–December 1967	April 1968

REFERENCES

(*1*) COLORADO STATE DEPARTMENT OF PUBLIC HEALTH, OCCUPATIONAL AND RADIOLOGICAL HEALTH DIVISION. Colorado milk network, October–December 1964 and summary 1962–1964. Radiol Health Data 6:202–204 (April 1965); January 1965–June 1966. Radiol Health Data Rep 7:573–575 (October 1966).

(*2*) INDIANA STATE BOARD OF HEALTH, BUREAU OF ENVIRONMENTAL SANITATION. Indiana milk network, April–June 1965. Radiol Health Data 6:612–614 (November 1965).

(*3*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and P. KAHN. Improved determination of strontium–90 in milk by ion-exchange method. Anal Chem 33:1306–1309 (September 1961).

(*4*) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

(*5*) PORTER, C., R. AUGUSTINE, J. MATUSEK, JR., and M. CARTER. Procedures for determining stable nuclides in environmental samples, PHS No. 999–RH–10. Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402 (January 1965).

(*6*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

(*7*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	July–December 1967	May 1968
Tri-City Diet, *HASL*	April–December 1967	June 1968
United Kingdom Diet, *ARCRL*	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples, October–December 1967 and Annual Summary 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions and 8 auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, and other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

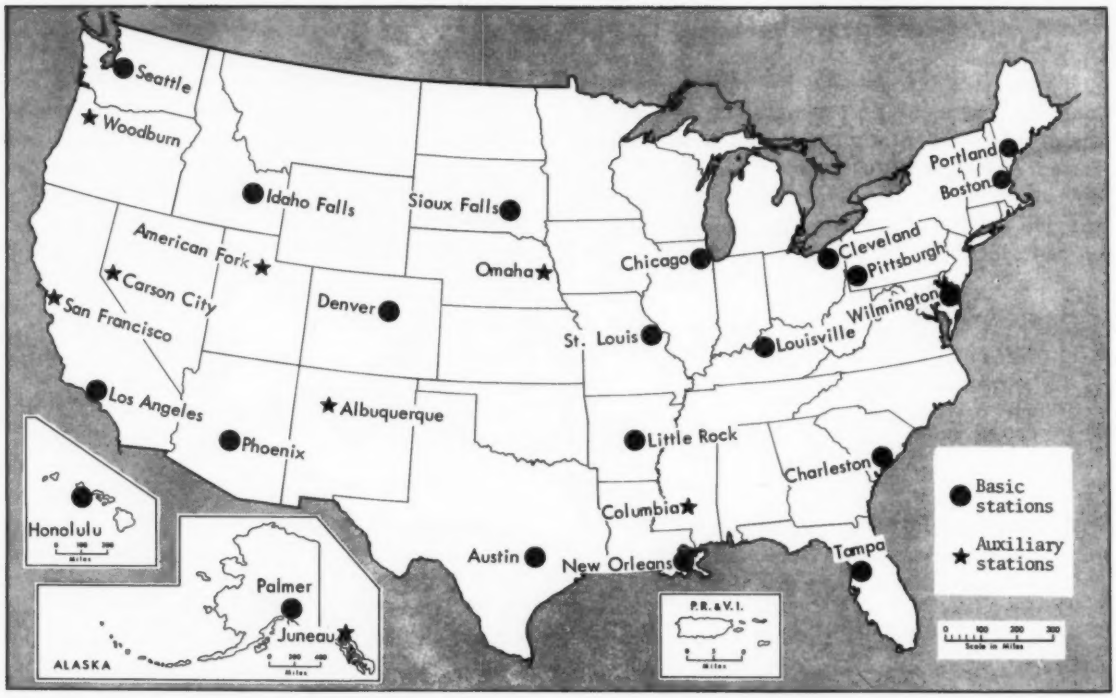

Figure 1. Institutional diet sampling locations as of September 1967

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.78 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (4).

Strontium–90 dietary intake during this period averaged 14 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (5). Cesium–137 intakes averaged 26 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium–89	5 pCi/kg
Strontium–90	2 pCi/kg
Iodine–131	10 pCi/kg
Cesium–137	10 pCi/kg
Barium–140	10 pCi/kg
Radium–226	0.1 pCi/kg

Data from eight auxiliary stations are included for general information and presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children whose ages range from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the National Center for Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9-12 years of age), October–December 1967

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	Oct.	1.70	0.6	1.0	1.3	2.3	10	18	28	48	0.5	0.8
	Nov.	1.82	.5	0.9	1.3	2.3	5	9	17	31	.4	.7
	Dec.	1.65	.5	.9	1.5	2.5	6	10	26	43	.6	1.0
Ariz: Phoenix	Oct.	2.07	.6	1.3	1.6	3.2	12	24	0	0	.6	1.2
	Nov.	1.98	.8	1.7	1.4	2.8	11	22	15	30	.7	1.4
	Dec.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ark: Little Rock	Oct.	1.76	.7	1.2	1.6	2.9	10	17	14	25	.5	.9
	Nov.	1.55	.6	0.9	1.4	2.2	9	14	0	0	.4	.6
	Dec.	1.94	.5	1.0	1.6	3.1	10	19	0	0	.5	1.0
Calif: Los Angeles	Oct.	1.69	.4	.6	1.2	2.0	3	5	0	0	.5	.8
	Nov.	2.02	.4	.8	1.2	2.4	3	7	0	0	.5	1.0
	Dec.	1.48	.4	.6	1.5	2.2	6	9	0	0	.5	.7
Colo: Denver	Oct [a]	2.43	.7	1.7	1.3	3.2	8	18	19	46	.5	1.2
	Nov [a]	2.16	.8	1.6	1.6	3.5	3	7	13	28	.6	1.3
	Dec.	2.31	.7	1.7	1.5	3.5	7	17	14	32	.5	1.2
Del: Wilmington	Oct.	2.14	.8	1.6	1.7	3.7	10	21	0	0	.6	1.3
	Nov.	2.29	.6	1.5	1.6	3.6	8	18	12	27	.7	1.6
	Dec.	2.08	.7	1.4	1.6	3.3	7	15	14	29	.7	1.5
Fla: Tampa	Oct.	2.11	.6	1.3	1.6	3.3	6	12	29	61	.5	1.1
	Nov.	2.09	.5	1.1	1.8	3.8	4	9	44	92	.7	1.5
	Dec.	2.15	.6	1.3	1.8	4.0	6	12	54	116	.7	1.5
Hawaii: Honolulu	Oct.	2.16	.5	1.1	1.2	2.7	4	8	12	26	.4	.9
	Nov.	2.31	NA	NA	1.4	3.3	2	5	18	42	.5	1.2
	Dec.	2.26	.9	2.1	1.4	3.1	4	8	12	27	.4	.9
Idaho: Idaho Falls	Oct [a]	1.93	1.0	1.9	1.9	3.6	7	13	16	31	.7	1.4
	Nov [a]	2.12	1.1	2.3	1.8	3.8	7	15	14	30	.5	1.1
	Dec [a]	2.18	1.2	2.7	1.6	3.5	7	16	13	28	.6	1.3
Ill: Chicago	Oct [a]	1.30	.7	.9	2.0	2.5	5	6	15	20	.7	.9
	Nov.	1.67	.8	1.4	2.0	3.3	7	12	15	25	.7	1.2
	Dec [a]	1.46	.7	1.0	1.7	2.5	7	10	24	35	.7	1.0
Ky: Louisville	Oct [a]	1.39	.7	1.0	1.8	2.5	9	12	12	17	.5	.7
	Nov [a]	1.82	.7	1.2	1.3	2.4	9	16	0	0	.4	.7
	Dec.	1.44	.8	1.1	1.7	2.4	9	17	0	0	.3	.4
La: New Orleans	Oct.	1.51	.6	.8	1.7	2.5	10	14	18	27	.5	.8
	Nov.	2.00	.8	1.6	1.8	3.6	12	24	19	38	.6	1.2
	Dec.	1.96	.7	1.4	1.6	3.2	12	23	14	27	.4	.8
Mass: Boston	Oct.	1.54	.8	1.2	1.6	2.4	9	14	24	37	.5	.8
	Nov.	1.67	.6	1.1	1.7	2.9	8	13	28	47	.9	1.5
	Dec.	1.50	.8	1.2	1.6	2.4	13	19	17	26	.6	.9
Mo: St. Louis	Oct.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Nov.	2.12	1.0	2.1	1.9	4.0	12	25	16	34	.7	1.5
	Dec.	2.53	1.1	2.8	1.9	4.8	8	21	13	33	.6	1.5
Ohio: Cleveland	Oct.	1.29	.6	.7	2.0	2.6	6	8	11	14	.5	.6
	Nov.	1.20	.6	.7	1.9	2.3	6	7	0	0	.7	.8
	Dec.	1.34	.6	.7	2.0	2.6	7	9	11	15	.8	1.1
Pa: Pittsburgh	Oct.	2.23	.6	1.3	1.4	3.1	6	14	0	0	.5	1.1
	Nov.	2.14	.6	1.3	1.4	3.0	8	16	24	51	.9	1.9
	Dec.	2.25	.6	1.4	1.5	3.4	8	19	18	40	.6	1.4
S. C: Charleston	Oct.	1.48	.7	1.0	1.4	2.0	9	14	26	38	.8	1.2
	Nov [a]	2.03	.6	1.3	1.5	3.1	11	22	18	37	1.2	2.4
	Dec.	1.49	.6	.9	1.5	2.3	12	18	16	24	1.0	1.5
S. Dak: Sioux Falls	Oct.	1.22	.6	.8	1.9	2.3	7	9	14	17	.7	.8
	Nov.	1.06	.7	.7	1.5	1.5	5	5	15	16	.8	.8
	Dec.	1.21	.6	.8	1.7	2.0	4	4	15	18	.5	.6
Tex: Austin	Oct.	1.70	.5	.9	1.3	2.1	4	7	0	0	.5	.8
	Nov.	1.80	.6	1.0	1.4	2.5	6	10	0	0	.5	.9
	Dec.	1.75	.6	1.0	1.5	2.6	7	13	0	0	.5	.9
Maine: Portland	Oct.	1.40	.8	1.0	1.8	2.5	10	15	30	42	.9	1.3
	Nov.	1.30	.8	1.0	1.6	2.1	10	13	25	32	1.1	1.4
	Dec.	1.44	.9	1.3	1.7	2.4	14	21	26	37	.7	1.0
Wash: Seattle	Oct [a]	2.27	.5	1.1	1.3	2.9	5	12	20	45	.4	.9
	Nov [a]	2.12	.5	1.0	1.4	3.0	6	14	12	25	.3	.6
	Dec [a]	1.79	.9	1.7	1.9	3.4	4	6	22	39	.4	.7
Institutional average	Oct.	1.73	0.6	1.1	1.6	2.6	8	13	14	22	0.6	1.0
	Nov.	1.81	0.7	1.2	1.6	2.8	7	13	16	29	0.7	1.2
	Dec.	1.81	0.7	1.3	1.6	2.9	8	15	15	27	0.6	1.1

[a] Since food samples were collected from two or more children who were not between the ages of 9-12, data for this month was not used in institutional average.

NA, no analysis.

NS, no sample.

Note: Since iodine-131, barium-140 and strontium-89 were not detectable at most stations during the fourth quarter 1967 no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in October for Alaska, and Colorado, 11 pCi/kg. Barium-140 was also reported in December for Washington, 16 pCi/kg. Strontium-89 was reported in November for Colorado, 10 pCi/kg.

Table 2. Concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals at auxiliary stations, October–December 1967

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau	Oct	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Nov	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Dec	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Calif: San Francisco	Oct	2.65	.6	1.7	1.4	3.7	3	9	11	29	0.9	2.4
	Nov	2.28	.8	1.8	1.4	3.3	11	24	12	27	.7	1.6
	Dec	2.50	1.0	2.4	1.5	3.8	4	9	0	0	.6	1.5
Miss: Columbia	Oct	2.15	1.0	2.1	1.5	3.2	11	23	18	39	.9	1.9
	Nov	2.03	1.0	2.0	1.5	3.1	14	28	19	39	.9	1.8
	Dec	2.22	1.0	2.1	1.4	3.1	12	28	0	0	.6	1.3
Nebr: Omaha	Oct	2.13	1.0	2.2	1.8	3.8	7	15	0	0	.5	1.1
	Nov	2.28	.8	1.9	1.8	4.1	6	14	16	36	.4	.9
	Dec	2.08	.9	1.9	1.9	3.9	5	10	0	0	1.3	2.7
Nev: Carson City	Oct	1.25	.6	.7	1.7	2.1	6	8	17	21	.7	.9
	Nov	1.51	.6	1.0	1.6	2.5	3	4	15	23	.6	.9
	Dec	1.76	.8	1.5	1.7	3.0	6	11	0	0	.6	1.1
N. Mex: Albuquerque	Oct	2.22	.9	1.9	1.8	3.9	4	9	0	0	.3	.7
	Nov	2.56	.8	2.1	1.5	3.9	4	11	18	46	.5	1.3
	Dec	1.44	.6	.9	1.6	2.3	4	6	15	22	.4	.6
Ore: Woodburn	Oct	2.48	.5	1.3	1.6	4.1	6	15	19	47	.5	1.2
	Nov	2.57	.6	1.5	1.8	4.7	5	13	31	80	.4	1.0
	Dec	2.35	.7	1.6	1.5	3.5	3	7	12	28	.6	1.4
Utah: American Fork	Oct	2.22	.4	.9	.8	1.8	6	12	12	27	.5	1.1
	Nov	1.80	.7	1.3	1.4	2.6	6	10	0	0	.6	1.1
	Dec	1.94	.5	1.0	1.4	2.6	5	9	0	0	.3	.6
Institutional average	Oct	2.16	0.7	1.5	1.5	3.2	6	13	11	23	0.6	1.3
	Nov	2.15	0.8	1.7	1.6	3.5	7	15	16	36	0.6	1.2
	Dec	2.04	0.8	1.6	1.6	3.2	6	11	4	7	0.6	1.3

NA, no analysis.
NS, no sample.
Note: Since iodine-131, barium-140, and strontium-89 were not detectable at most stations during the fourth quarter 1967, no provision was made for these nuclides in the table. The few exceptions are as follows: barium-140 was reported in October for California, 14 pCi/kg; and Nevada, 11 pCi/kg. Barium-140 was also reported in December for New Mexico, 13 pCi/kg. Strontium-89 was reported in November for Oregon, 6 pCi/kg.

Table 3. 1967 annual average concentration and intake of stable elements and radionuclides in Institutional total diets of children (9-12 years of age)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
		g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	1.60	0.5	0.8	1.4	2.2	8	13	27	42	0.6	1.0
Ariz: Phoenix	1.92	.7	1.3	1.5	2.8	6	12	7	13	.7	1.3
Ark: Little Rock	1.49	.6	.9	1.6	2.4	13	19	14	21	.8	1.1
Calif: Los Angeles	1.96	.7	1.4	1.5	2.9	4	9	6	13	.5	1.1
Colo: Denver	2.25	.7	1.5	1.5	3.4	7	15	14	32	.6	1.4
Del: Wilmington	2.20	.7	1.6	1.8	3.9	9	20	14	32	.7	1.5
Fla: Tampa	2.09	.6	1.2	1.8	3.7	7	14	41	86	1.0	2.1
Hawaii: Honolulu	2.27	.4	1.0	1.4	3.2	3	6	15	35	.5	1.2
Idaho: Idaho Falls [a]	1.95	1.1	2.1	1.8	3.6	8	16	16	32	.7	1.3
Ill: Chicago	1.62	.7	1.2	1.7	2.8	7	12	17	27	.7	1.1
Ky: Louisville	1.59	.8	1.2	1.7	2.6	10	18	10	16	1.6	2.4
La: New Orleans	1.82	.7	1.2	1.7	3.1	13	23	21	40	.7	1.3
Maine: Portland	1.30	.8	1.0	1.8	2.2	12	15	25	33	.8	1.0
Mass: Boston	1.66	.7	1.3	1.6	2.7	11	18	26	44	.6	1.0
Mo: St. Louis	1.74	.9	1.6	1.8	3.1	12	20	14	24	.7	1.2
Ohio: Cleveland	1.34	.6	.8	2.0	2.6	7	10	11	15	.8	1.0
Pa: Pittsburgh	2.21	.6	1.3	1.5	3.3	7	13	14	31	.6	1.4
S. C: Charleston	1.61	.6	1.0	1.4	2.3	11	17	26	42	1.4	2.2
S. Dak: Sioux Falls	1.19	.7	.8	1.7	2.0	6	7	11	13	.7	0.8
Tex: Austin	1.71	.6	1.0	1.3	2.3	6	9	4	7	.8	1.4
Wash: Seattle [a]	1.90	.7	1.3	1.5	2.8	7	13	20	40	.5	1.0
Institutional average	1.77	0.7	1.2	1.6	2.8	8	14	17	30	0.8	1.3

[a] This data was not included in the institutional average since all children were not between 9-12 years of age.
[b] Institution change in August 1967, from Burlington, Vt. to Portland, Maine.
Note: Since iodine-131, barium-140 and strontium-89 were not detectable at most stations during the year 1967, no provision was made for these nuclides in the table. The exceptions for January 1967 are, 20 pCi/kg of iodine-131 reported for Louisiana and Arizona. Barium-140 was reported for the following institutions: Alaska, 20 pCi/kg; Utah, 17 pCi/kg; and Washington, 30 pCi/kg.
May 1967: 13 pCi/kg of iodine-131 was reported for Arizona.
September 1967: 18 pCi/kg of barium-140 was reported in Arizona.
October 1967: 11 pCi/kg of barium-140 was reported for Alaska and Colorado.
November 1967: 10 pCi/kg of strontium-89 was reported in Colorado.
December 1967: 11 pCi/kg of barium-140 was reported in Colorado and 16 pCi/kg in Washington.

Table 4. 1967 annual average concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations)

Location of Institution	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
		g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau	2.55	0.3	0.8	1.0	2.6	4	10	8	19	0.4	1.0
Calif: San Francisco	2.42	.7	1.7	1.5	3.5	5	12	10	26	.8	1.9
Miss: Columbia	2.16	.9	2.0	1.5	3.2	11	24	18	38	1.3	2.8
Nebr: Omaha	2.14	.9	1.9	1.8	3.9	7	15	11	24	.9	1.8
Nev: Carson City	1.44	.7	1.0	1.7	2.4	5	7	13	18	.7	1.1
N. Mex: Albuquerque	2.32	.8	1.9	1.7	3.9	4	10	6	14	.6	1.3
Oregon: Woodburn	2.46	.6	1.4	1.7	4.1	5	14	19	48	.5	1.3
Utah: American Folk	1.93	.6	1.1	1.2	2.3	5	8	6	11	.5	0.9
Institutional average	2.18	0.7	1.5	1.5	3.2	6	12	11	25	0.7	1.5

Note: Since iodine-131, barium-140, and strontium-89 were not detectable at most stations during the year 1967 no provision was made for these nuclides in the table. The exceptions are as follows:
January 1967: 27 pCi/kg of iodine-131 was reported in Mississippi and 29 pCi/kg in Nevada. 17 pCi/kg of barium-140 was reported in Utah, 31 pCi/kg in Nevada.
March 1967: Barium-140 was reported for Oregon, 13 pCi/kg.
May 1967: 11 pCi/kg of iodine-131 was reported in Oregon and Utah.
October 1967: Barium-140 was reported in California, 14 pCi/kg in Nevada.
November 1967: 6 pCi/kg of strontium-89 was reported in Nevada.
December 1967: 13 pCi/kg of barium-140 was reported in New Mexico.

Annual averages

Annual average radionuclide concentrations and intakes are presented in tables 3 and 4 for the basic and auxiliary stations. During 1967, the annual average intake for the basic stations was 1.77 kg/day as compared to 2.18 kg/day in the auxiliary stations. This is due to the fact that the basic stations sample diets of children from ages 9-12 while the auxiliary stations usually sample diets of children who are older and consume more food. The levels of radionuclide intake in both the basic and auxiliary stations were similar.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1967	January 1968
July–September 1967	April 1968

REFERENCES

(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, April–June 1965. Radiol Health Data 7:92–98 (February 1966).

(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Radiol Health Data 6:691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water Sampling Program	Period reported	Last presented
California	January–June 1967	June 1968
Colorado River Basin	1965–1966	May 1968
Coast Guard	January–December 1966	November 1967
Minnesota	January–June 1967	January 1968
New York	January–May 1967	January 1968
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968
Washington	July 1965–June 1966	August 1967

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, January 1968

Division of Pollution Surveillance
Federal Water Pollution Control
Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service

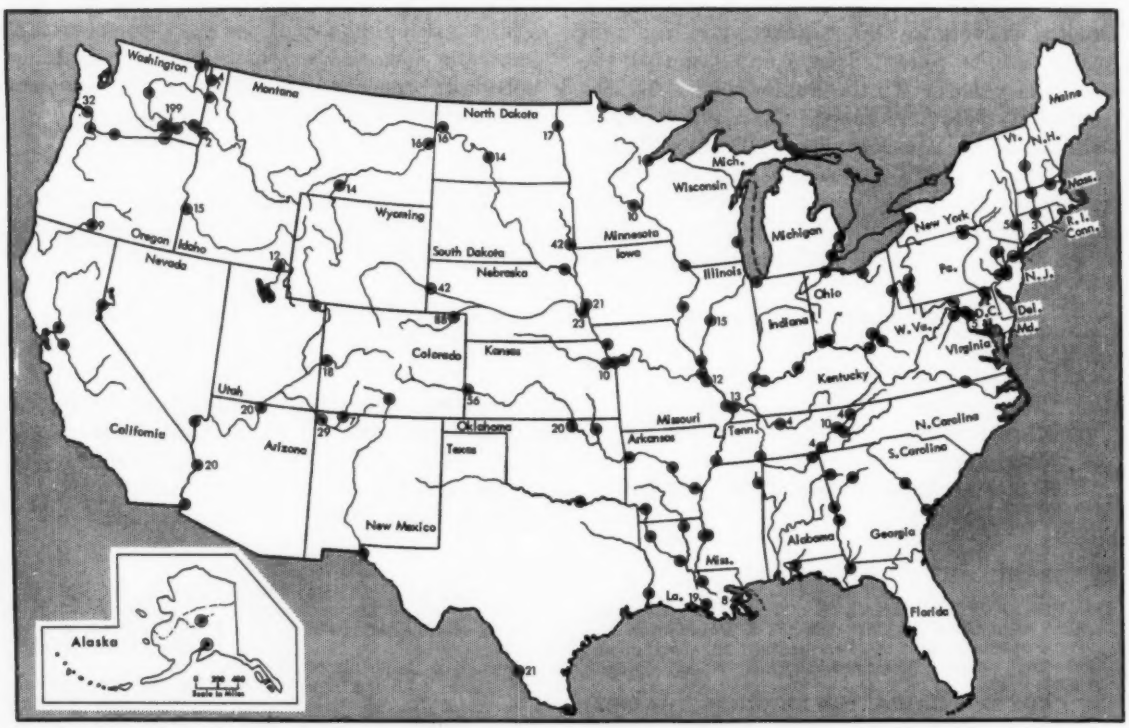

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, January 1968

Table 1. Radioactivity in raw surface waters, January 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	1	2	2	5	7
Arkansas River:						
Coolidge, Kans.	<1	46	46	5	51	56
Ponca City, Okla.	0	6	6	1	19	20
Atchafalaya River:						
Morgan City, La.	5	0	5	12	7	19
Bear River:						
Preston, Idaho	0	3	3	0	12	12
Big Horn River:						
Hardin, Mont.	0	5	5	1	13	14
Big Sioux River:						
Sioux Falls, S. Dak.	0	3	3	1	41	42
Clearwater River:						
Lewiston, Idaho	0	0	0	<1	2	2
Clinch River:						
Clinton, Tenn.	0	0	0	0	4	4
Kingston, Tenn. [a]	0	0	0	1	9	10
Colorado River:						
Loma, Colo.	2	4	6	7	11	18
Page, Ariz.	0	6	6	<1	20	20
Parker Dam, Calif.-Ariz.	0	7	7	0	20	20
Columbia River:						
Pasco, Wash. [a]	0	1	1	28	171	199
Clatskanie, Ore.	0	<1	<1	5	27	32
Connecticut River:						
Enfield Dam, Conn.	0	0	0	0	3	3
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	0	4	4
Great Lakes:						
Duluth, Minn.	0	0	0	0	1	1
Hudson River:						
Poughkeepsie, N. Y.	0	0	0	1	4	5
Illinois River:						
Peoria, Ill.	0	2	2	3	12	15
Kansas River:						
DeSoto, Kans.	0	3	3	2	8	10
Klamath River:						
Keno, Ore.	0	0	0	1	8	9
Mississippi River:						
St. Paul, Minn.	0	0	0	1	9	10
E. St. Louis, Ill.	1	0	1	7	5	12
New Orleans, La.	3	0	3	6	2	8
Missouri River:						
Williston, N. Dak.	0	4	4	3	13	16
Bismarck, N. Dak.	0	3	3	1	13	14
St. Joseph, Mo.	0	5	5	2	19	21
North Platte River:						
Henry, Nebr.	1	26	27	5	37	42
Ohio River:						
Cairo, Ill.	2	0	2	8	5	13
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	<1	4	4
Platte River:						
Plattsmouth, Nebr.	1	5	6	2	21	23
Potomac River:						
Washington, D. C.	0	0	0	1	4	5
Rainy River:						
Baudette, Minn.	0	0	0	4	1	5
Red River, North:						
Grand Forks, N. Dak.	0	1	1	1	16	17
Rio Grande:						
Laredo, Tex.	1	6	7	8	13	21
San Juan River:						
Shiprock, N. Mex.	7	2	9	21	8	29
Savannah River:						
Port Wentworth, Ga. [a]	<1	0	<1	2	7	9
Snake River:						
Payette, Idaho	0	6	6	<1	15	15
South Platte River:						
Julesburg, Colo.	8	46	54	21	67	88
Tennessee River:						
Chattanooga, Tenn.	0	0	0	1	3	4
Yellowstone River:						
Sidney, Mont.	0	3	3	0	16	16
Maximum	8	46	54	28	171	199
Minimum	0	0	0	0	1	1

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During January, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During January 1968, Pasco, Wash., on the Columbia River increased in average value to more than 150 pCi/liter on beta radioactivity for dissolved solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radiactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

Radioactivity in Florida Waters, 1965 and 1966 [1]

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health samples raw surface water from locations in 13 hydrological subbasins. In nine of these subbasins, raw ground water is also sampled. The samples are collected on a variable frequency and analyzed for gross alpha and beta radioactivity.

Figure 1 shows the locations of the surface water subbasins from which samples are obtained. Average gross alpha and gross beta radioactivity levels in raw surface waters during 1965 are presented in table 1; table 2 gives the radioactivity levels in ground waters.

In addition to the sampling done by the Florida State Board of Health, the Bioenvironmental Engineering Research Laboratory, University of Florida, samples raw surface water and water supplies in Alachua County and analyzes the samples for gross alpha and gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1965 are summarized in table 3 as quarterly and yearly averages.

The yearly average beta radioactivity in surface waters was slightly higher than that in ground waters. This additional beta radioactivity in surface waters can be attributed to fallout. The alpha radioactivity, which is attributed to natural radioactivity of minerals, is the same for ground and surface water.

During 1966, 64 samples out of a total of 421 collected from the 238 sampling sites showed gross beta radioactivity greater than the minimum reporting concentration of 10

[1] Data taken from "Report of Florida Radiological Data, Environmental Monitoring Programs, 1965" and "Report of Florida Radiological Data, Environmental Monitoring Programs, 1966," Florida State Board of Health, Bureau of Preventable Diseases, Division of Radiological Health, Jacksonville, Fla.

Figure 1. Hydrological surface subbasins in Florida

Table 1. Gross alpha and beta radioactivity in raw surface water, 1965

Location subbasin	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys-Nassau River			[a] (4)	(4)					(4)	(4)
			0.7	68.0					0.7	68.0
St. Johns River	(25)	(25)	(19)	(19)	(32)	(32)	(27)	(27)	(103)	(103)
	0.6	13.5	0.6	42.2	0.1	24.7	0.1	16.9	0.3	23.2
Suwannee River	(7)	(7)					(6)	(6)	(13)	(13)
	0.2	19.4					0.1	7.6	0.2	14.0
Ochlockonee-St. Marys River	(3)	(3)			(8)	(8)	(2)	(2)	(13)	(13)
	0.7	9.7			ND	6.6	ND	4.0	0.2	7.0
Withlacoochee River									NS	NS
Tampa Bay Area	(4)	(4)	(3)	(3)			(5)	(5)	(12)	(12)
	0.5	17.2	0.3	32.3			ND	10.8	0.2	18.3
Peace River	(1)	(1)			(4)	(4)			(5)	(5)
	0.8	19.0			0.1	8.0			0.2	10.2
Kissimmee River	(1)	(1)	(1)	(1)	(4)	(4)	(5)	(5)	(11)	(11)
	0.2	29.0	0.3	49.0	0.5	19.7	ND	18.6	0.2	22.7
Florida East Coastal area	(29)	(29)	(30)	(30)	(36)	(36)	(21)	(21)	(116)	(116)
	0.3	27.7	0.5	55.1	ND	29.3	ND	22.8	0.2	34.4
Lower Florida area	(7)	(7)	(12)	(12)	(8)	(8)	(12)	(12)	(39)	(39)
	0.2	7.2	0.3	20.7	ND	6.0	ND	6.7	0.1	11.0
Apalachicola River	(1)	(1)					(3)	(3)	(4)	(4)
	0.4	10.0					ND	120	0.1	92.5
Choctawhatchee River	(3)	(3)					(6)	(6)	(9)	(9)
	0.3	6.0					ND	5.3	0.1	5.5
Perdido-Escambia Rivers	(4)	(4)					(4)	(4)	(8)	(8)
	0.3	11.0					0.5	5.5	0.4	8.2
Average	(85)	(85)	(69)	(69)	(92)	(92)	(91)	(91)		
	0.4	18.2	0.5	45.2	0.1	22.4	0.1	17.9		

[a] Number in parentheses indicates number of samples.
ND, nondetectable.
NS, no sample reported.

Table 2. Gross alpha and beta radioactivity in ground water, 1965

Location subbasin	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
St. Marys-Nassau River			[a] (1)	(1)					(1)	(1)
			ND	4.0					ND	4.0
St. Johns River					(2)	(2)	(2)	(2)	(4)	(4)
					ND	ND	0.2	ND	0.1	ND
Suwannee River	(1)	(1)					(1)	(1)	(2)	(2)
	0.8	10.0					ND	ND	0.4	5.0
Ochlockonee-St. Marys River					(1)	(1)	(1)	(1)	(2)	(2)
					ND	ND	ND	ND	ND	ND
Withlacoochee River									NS	NS
Tampa Bay area	(2)	(2)							(2)	(2)
	0.3	45.0							0.3	45.0
Peace River									NS	NS
Kissimmee River					(1)	(1)			(1)	(1)
					ND	ND			ND	ND
Florida East Coastal area									NS	NS
Lower Florida area			(2)	(2)			(2)	(2)	(4)	(4)
			5.3	127.0			1.0	68.0	3.1	97.5
Apalachicola River									NS	NS
Choctawhatchee River	(7)	(7)					(4)	(4)	(11)	(11)
	0.3	5.4					ND	3.3	0.2	4.6
Perdido-Escambia Rivers							(1)	(1)	(1)	(1)
							ND	6.0	ND	6.0
Average	(10)	(10)	(3)	(3)	(4)	(4)	(11)	(11)		
	0.4	13.8	3.5	86.0	ND	ND	0.2	12.9		

[a] Number in parentheses indicates number of samples.
ND, nondetectable.
NS, no sample reported.

Table 3. Gross alpha and beta radioactivity in raw water, 1965

Location	Radioactivity concentration (pCi/liter)									
	January-March		April-June		July-September		October-December		Yearly average	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Alachua County: 19 sampling locations	0.6	8.5	0.8	8.2	0.1	8.3	0.4	8.1	0.5	8.3
City of Gainesville	0.1	5.0	0.1	4.3	0.1	4.3	0.1	4.8	0.1	4.6

pCi/liter. Those 64 samples averaged 36 pCi/liter of gross beta radioactivity. Only 5 of the 421 samples, which averaged 10 pCi/liter of gross alpha radioactivity, were greater than the minimum reporting concentration of 7 pCi/liter. The average gross beta radioactivity in water supplies is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (*1*).

The Bioenvironmental Engineering Research Laboratory reported that only 32 of the municipal water samples (City of Gainesville) and 50 of the surface water samples (Alachua County), were greater than the reporting minimum in 1966. The 32 municipal water supply samples averaged 16 pCi/liter of gross beta radioactivity and the 50 surface water samples averaged 19 pCi/liter of gross beta radioactivity.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service drinking water, standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	January–June 1967	March 1968
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	April–June 1967	November 1967

1. Radiation Alert Network March 1968

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Center for Radiological Health officials by mail or telephone, depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during March 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting stations.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, March 1968

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Pptn	Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	31	3	7.06	0.30	2.51	Nov 67	75	2	54	6
Alaska:	Adak	[b]					Apr 68	[c]			
	Anchorage	20	1	.38	.00	.01	Dec 67	1	1	1	0
	Attu Island	[b]					May 68	[c]			
	Fairbanks	[b]					Jan 68	[c]			
	Juneau	20	13	.00	.00	.00	Feb 68	184	13	184	0
	Kodiak	21		.44	.00	.29	Mar 68	[c]			
	Nome	[b]					July 68	[c]			
	Pt. Barrow	31		1.20	1.03	1.09	June 68	[c]			
	St. Paul Island	30		.96	.42	.45	Oct 67	[c]			
Ariz:	Phoenix	21		11.57	.93	5.15	Feb 68	[c]			
Ark:	Little Rock	13	3	2.85	.49	1.08	Dec 67	88	0	0	[•]
Calif:	Berkeley	20	6	.73	.00	.24	Mar 68	99	6	99	0
	Los Angeles	21	4	2.08	.28	1.00	July 68	63	4	63	0
C. Z:	Ancon	17		3.12	1.20	2.10	Mar 68	[c]			
Colo:	Denver	21	2	4.20	.79	1.83	Mar 68	13	[d]	[d]	[d]
Conn:	Hartford	19	8	.51	.21	.28	Jan 68	111	8	111	36
Del:	Dover	21		1.05	.00	.40	Nov 67	[c]			
D. C:	Washington	29	6	2.16	.00	.93	June 68	101	6	101	80
Fla:	Jacksonville	20	4	2.43	.33	.59	Dec 67	34	4	34	0
	Miami	18	4	.75	.24	.50	Jan 68	14	4	14	0
Ga:	Atlanta	21	4	1.62	.80	1.12	Oct 67	113	0	0	[•]
Guam:	Agana	21		.58	.00	.32	Nov 67	[c]			
Hawaii:	Honolulu	30	3	1.20	.30	.57	May 68	35	[d]	[d]	[d]
Idaho:	Boise	21	6	4.00	.65	1.88	May 68	25	6	25	2
Ill:	Springfield	21	3	3.13	.35	.97	June 68	41	0	0	[•]
Ind:	Indianapolis	20	6	2.18	.77	1.32	Oct 67	33	6	33	62
Iowa:	Iowa City	21	2	2.42	.65	1.20	Mar 68	21	1	7	0
Kans:	Topeka	21	3	3.74	.56	1.51	Dec 67	3	3	3	0
Ky:	Frankfort	10	5	.68	.30	.43	June 68	37	5	37	64
La:	New Orleans	20	4	1.00	.22	.53	June 68	45	[d]	[d]	[d]
Maine:	Augusta	21	8	1.04	.00	.40	July 68	118	8	118	0
Md:	Baltimore	20	4	4.88	.00	.85	Jan 68	35	4	35	11
	Rockville	[b]					May 68	86	[d]	[d]	[d]
Mass:	Lawrence	21	9	1.78	.00	.33	Nov 67	174	0	0	[•]
	Winchester	21	7	2.49	.00	.21	Apr 68	108	7	108	0
Mich:	Lansing	16		2.31	.50	1.03	May 68	[c]			
Minn:	Minneapolis	21	7	.66	.10	.23	Nov 67	54	7	54	41
Miss:	Jackson	18	4	1.00	.00	.54	July 68	61	4	61	52
Mo:	Jefferson City	21	6	1.42	.36	.71	Oct 67	29	6	29	2
Mont:	Helena	20	2	2.80	.23	1.05	Apr 68	12	2	12	16
Nebr:	Lincoln	19		4.01	1.11	1.97	Oct 67	[c]			
Nev:	Las Vegas	16		3.42	1.14	2.18	Jan 68	[c]			
N. H:	Concord	18		1.09	.49	.65	June 68	[c]			
N. J.	Trenton	19	4	.83	.10	.33	July 68	135	4	135	0
N. Mex:	Santa Fe	17	3	1.26	.23	.66	Apr 68	15	3	15	0
N. Y:	Albany	21	6	.94	.20	.52	Oct 67	59	6	59	46
	Buffalo	21		.95	.29	.50	Mar 68	[c]			
	New York City	21		.50	.30	.37	Apr 68	[c]			
N. C:	Gastonia	17	2	13.71	.53	3.71	Mar 68	50	[d]	[d]	[d]
N. Dak:	Bismarck	17	2	3.36	.00	.79	June 68	18	0	0	[•]
Ohio:	Cincinnati	18		2.46	.73	1.25	Nov 67	[c]			
	Columbus	19	6	1.89	.33	.72	July 68	59	5	56	0
	Painesville	21	6	.95	.21	.39	Jan 68	32	6	32	5
Okla:	Oklahoma City	14	4	1.45	.00	.60	May 68	27	3	16	0
	Ponca City	21	5	1.16	.23	.58	Jan 68	48	5	48	0
Ore:	Portland	19	14	.97	.00	.32	Oct 67	72	14	72	0
Pa:	Harrisburg	17		2.26	.26	.94	Oct 67	[c]			
P. R:	San Juan	[b]					July 68	[c]			
R. I:	Providence	19	6	.76	.09	.29	May 68	175	0	0	[•]
S. C:	Columbia	8	4	.79	.17	.41	Apr 68	84	0	0	[•]
S. Dak:	Pierre	17		7.99	.97	2.45	Feb 68	[c]			
Tenn:	Nashville	16	7	1.84	.56	.89	May 68	111	7	111	0
Tex:	Austin	21	4	6.08	.62	2.63	Nov 67	61	[d]	[d]	[d]
	El Paso	20	4	6.93	.65	2.82	June 68	17	4	17	0
Utah:	Salt Lake City	30	8	2.10	.28	.83	July 68	76	1	10	0
Vt:	Barre	20	8	1.41	.23	.48	Dec 67	78	8	78	0
Va:	Richmond	17	6	.90	.20	.54	Dec 67	85	0	0	[•]
Wash:	Seattle	[b]	14				Dec 67	105	[d]	[d]	[d]
	Spokane	21	1	2.52	.93	1.41	Nov 67	1	0	0	[•]
W. Va:	Charleston	20	9	2.46	.22	.82	Apr 68	98	9	98	62
Wis:	Madison	21	2	.93	.25	.48	Dec 67	14	2	14	14
Wyo:	Cheyenne	21	1	5.53	.67	2.08	Jan 68	9	1	9	10
Network summary		1,324	263	13.71	0.00	1.00		62	5	54	14

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program).
[c] No precipitation samples collected.
[d] Indicates that the station is part of the plutonium in precipitation network. No gross beta measurements are done.
[•] Samples were collected but no field estimates were reported.

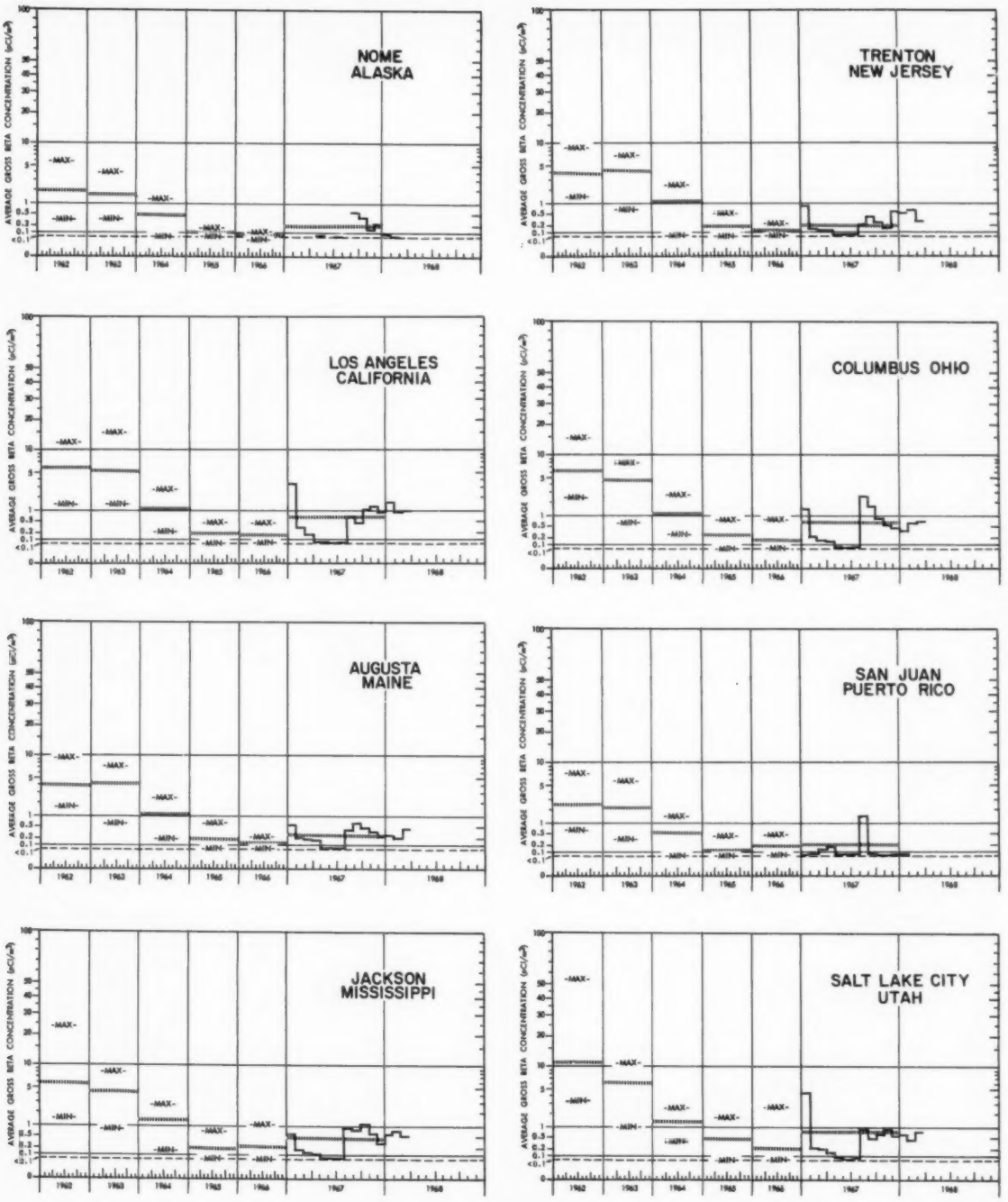

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1962–March 1968

2. Canadian Air and Precipitation Monitoring Program,[1] March 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2-6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for March 1968 are presented in table 2.

[1] Prepared from information and data in the April 1968 Monthly report "Data from Radiation Protection Program" Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, March 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.5	0.1	0.2	43	0.8
Coral Harbour	31	.2	.1	.1	23	1.2
Edmonton	31	.4	.1	.1	68	1.3
Ft. Churchill	31	.2	.0	.1	13	.5
Ft. William	31	.3	.1	.2	101	7.4
Fredericton	31	.4	.0	.2	50	5.3
Goose Bay	31	.2	.1	.1	17	1.6
Halifax	30	.3	.0	.2	9	1.2
Inuvik	31	.2	.1	.2	29	.3
Montreal	31	.4	.1	.2	61	5.1
Moosonee	31	.6	.1	.2	36	1.4
Ottawa	30	.3	.0	.2	85	7.0
Quebec	31	.3	.0	.2	77	5.8
Regina	31	.5	.0	.2	177	1.2
Resolute	27	.4	.0	.2	N8	N8
St. John's, Nfld.	31	.2	.0	.1	22	3.5
Saskatoon	31	.2	.0	.1	54	1.3
Saulte Ste Marie	26	.6	.1	.3	134	7.8
Toronto	31	.6	.0	.2	37	1.8
Vancouver	31	.2	.0	.1	61	8.5
Whitehorse	16	.2	.0	.1	108	.5
Windsor	31	.4	.0	.1	58	4.4
Winnipeg	31	.3	.0	.2	107	1.4
Yellowknife	31	.2	.1	.2	101	.6
Network summary	718	0.6	0.0	0.2	64	3.0

N8, no sample.

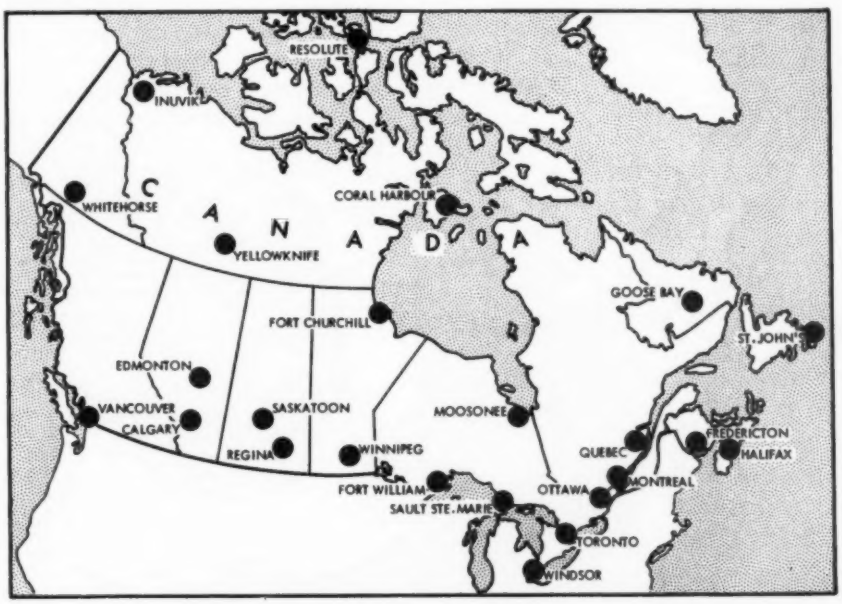

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program March 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of 5 samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta radioactivity in surface air during March 1968 are presented in table 3.

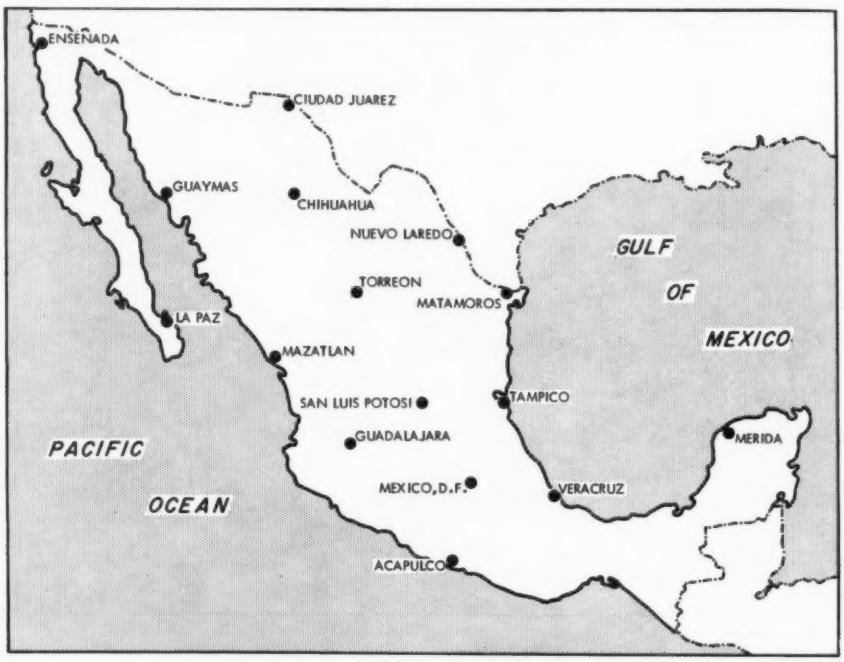

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, March 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average *
Acapulco	15	0.8	0.2	0.3
Chihuahua	14	1.3	.1	.6
Ciudad Juárez	2	.5	.1	—
Ensenada	1	.4	.4	—
Guadalajara	NS			
Guaymas	NS			
La Paz	5	.6	.2	.4
Matamoros	NS			
Mazatlán	8	1.0	.4	.6
Mérida	13	1.0	.1	.5
México, D. F.	11	.9	.2	.5
Nuevo Laredo	5	.9	.2	.4
San Luis Potosí	NS			
Tampico	12	1.0	.1	.3
Torreón	15	.9	.1	.4
Veracruz	2	.6	.2	—

NS, no sample collected.

4. Pan American Air Sampling Program March 1968

Pan American Health Organization and *U. S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports.* The March 1968 air monitoring results from the participating countries are given in table 4.

Table 4. Summary of gross beta radioactivity in Pan American surface air, March 1968

Station location	Number of samples	Gross beta radioacitivity (pCi/m³)		
		Maximum	Minimum	Average *
Argentina: Buenos Aires	16	0.03	0.01	0.02
Bolivia: La Paz	22	.03	.00	.01
Chile: Santiago	31	.03	.01	.02
Colombia: Bogota	20	.07	.02	.05
Ecuador: Guayaquil	21	.04	.01	.03
Jamaica: Kingston	14	.36	.03	.20
Peru: Lima	12	.02	.01	.01
Venezuela: Caracas	17	.28	.05	.13
West Indies: Trinidad	19	.17	.06	.10
Pan American summary	172	0.36	0.00	0.06

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 5. Pan American Air Sampling Program stations

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. National Center for Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada, (December 1961).

(*4*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*7*) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Oak Ridge Area, and the Portsmouth Area Gaseous Diffusion Plant.

[1] Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Oak Ridge Area January–June 1967 [2]

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

[2] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area, January–June 1967," Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in deter-

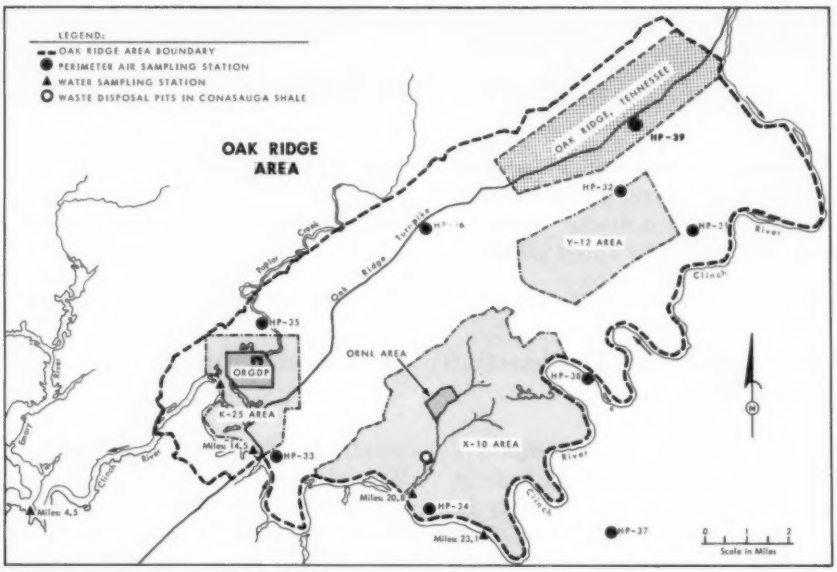

Figure 1. Oak Ridge area environmental sampling locations

mining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January–June 1967 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine–131. Of these, the maximum concentration detected was 0.12 pCi/m^3, the minimum was less than 0.010 pCi/m^3, and the average was 0.018 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine–131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area.

Table 1. Long-lived gross beta radioactivity of particulates in air Oak Ridge area, January–June 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard [a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard [a]
HP-31	26	0.16	0.16	HP-51	26	0.21	0.21
HP-32	26	.25	.25	HP-52	26	.16	.16
HP-33	26	.14	.14	HP-53	26	.14	.14
HP-34	26	.13	.13	HP-54	25	.15	.15
HP-35	26	.14	.14	HP-55	26	.22	.22
HP-36	182	.25	.25	HP-56	26	.15	.15
HP-37	26	.11	.11	HP-57	25	.17	.17
HP-38	26	.20	.20	HP-58	26	.18	.18
HP-39	26	.23	.23				
Average		0.18	0.18	Average		0.18	0.18

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m^3.

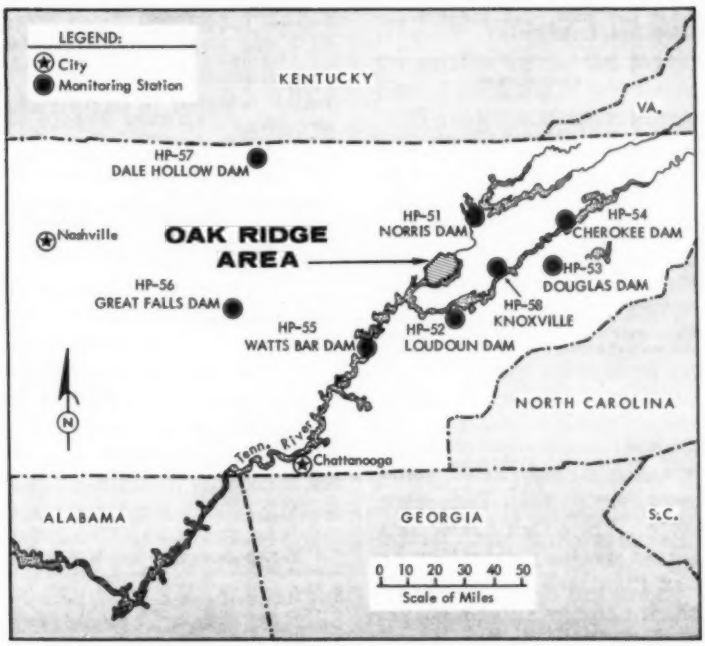

Figure 2. Remote air monitoring stations, Oak Ridge area

Table 2. Long-lived gross alpha radioactivity of particulates in air Oak Ridge area, January–June 1967

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard [a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard [a]
HP-31	26	0.004	0.20	HP-51	26	0.004	0.20
HP-32	26	.007	.35	HP-52	26	.004	.20
HP-33	26	.004	.20	HP-53	26	.004	.20
HP-34	26	.003	.15	HP-54	25	.003	.15
HP-35	26	.007	.35	HP-55	26	.004	.20
HP-36	182	.016	.80	HP-56	26	.004	.20
HP-37	26	.005	.25	HP-57	25	.004	.20
HP-38	26	.004	.20	HP-58	26	.005	.25
HP-39	26	.006	.30				
Average		0.006	0.30	Average		0.004	0.20

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m^3.

Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine–131 and strontium–90 detected in raw milk samples during the period are given in table 3.

Table 3. Radionuclides in raw milk, Oak Ridge area, January–June 1967

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum [a]	Average
Iodine-131:			
Immediate environs	930	<10	30
Remote environs	51	<10	8.2
Strontium-90:			
Immediate environs	59	4.5	27
Remote environs	40	5	24

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta particle emitters, uranium, and the transuramic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from January through June 1967.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For both samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 2×10^4 pCi/liter.

Table 4. Concentrations of major radionuclides in the Clinch River, January–June 1967

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River [a]		
	Mile: 23.1 [b] (Upstream)	Mile: 20.8 [c] (Outfall)	Mile: 4.5 (Downstream)
Strontium-90	0.5	0.7	1.0
Cerium-144	.2	<.1	0.2
Cesium-137	<.1	.4	1.6
Ruthenium-106	.4	1.2	.6
Cobalt-60	ND	.6	1.8
Zirconium-niobium-95	<.1	.1	.1
Gross beta	1.1	16	5.3

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River, see figure 1.
[b] Sampling station moved from Clinch River mile 41.5 to Melton Hill Dam CRM 23.1 about January 1, 1966.
[c] The concentrations at miles: 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.
ND indicates none was detected.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5 in terms of mR/hr.

Table 5. External gamma radiation levels[a], Oak Ridge area, January–June 1967

Location	Average dose rates (mR/hr)
Solway Gate	0.011
Y-12, East Portal	.011
Newcomb Road	.011
Gallaher Gate	.010
White Wing Gate	.012
Five locations	0.011

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/hr.

Discussion of data

The average air contamination levels for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants

(figures 1 and 2) were 0.18 percent of the AEC radiation protection standard for populations in the neighborhood of a controlled area. These levels are 1.8 times higher than those for the last half of 1966.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.30 percent and 0.20 percent, respectively, of the AEC radiation protection standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine–131 in air in the immediate environs of the plants was 0.018 pCi/m^3. This is approximately 0.018 percent of the AEC radiation standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine–131 in raw milk in the immediate and remote environs of the Oak Ridge area were 30 pCi/liter and 8.2 pCi/liter, respectively. The maximum concentration observed, 930 pCi/liter, occurred on January 11, 1967, approximately 7 days after the arrival in the Oak Ridge area of fallout containing fresh fission products. The average values fall within the limits of FRC Range II if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium–90 in raw milk in the immediate and remote environs of the controlled area were 27 pCi/liter and 24 pCi/liter, respectively. These levels fall near the lower limit of FRC Range II for transient rates of daily intake of strontium–90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 16 pCi/liter and 5.3 pCi/liter, respectively. These values are 0.76 percent and 0.38 percent of the weighted average AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.10 pCi/liter which is approximately 0.005 percent of the weighted average AEC radiation protection standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	January 1967
July–December 1966	August 1967

2. Portsmouth Area Gaseous Diffusion Plant [3] July–December 1967

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha-particle emitter and thorium–234 is a beta-particle and gamma-ray emitter, environmental monitoring is conducted for evidence of alpha-particle, beta particle and gamma-ray emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 3. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For the second half of 1967, the waterborne beta-gamma radioactivity and the background exposure increased over the first half values. The airborne alpha, airborne beta-gamma, and the waterborne alpha radioactivity remained essentially unchanged. For calendar year 1967 versus calendar year 1966, all values remained unchanged except for the waterborne beta-gamma radioactivity value which increased significantly. However, the 1967 value is only 0.24 percent of the AEC concentration standard.

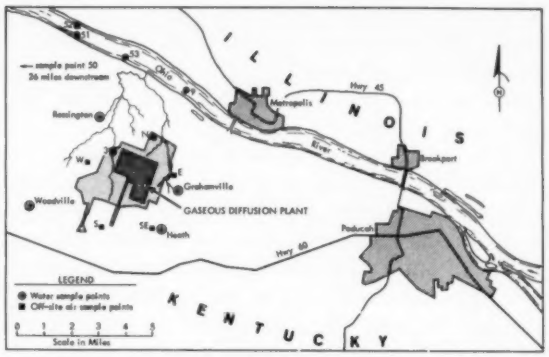

Figure 3. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Average background exposure rates remained unchanged from the 1966 values. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 6. The external gamma-radiation

[3] Data summarized from B. Kalman and S. H. Hulett: "Environmental Radiation Levels and Concentrations, Second Half and Annual Summaries 1967" (February 8, 1968).

Table 6. Environmental radioactivity, Portsmouth Plant, July–December 1967

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard [a]
Air:					
Alpha radioactivity, pCi/m³	122	0.5	<0.1	<0.1	0.23
Beta-gamma radioactivity, pCi/m³	122	1.0	<.1	<.1	.01
Water:					
Alpha radioactivity, pCi/liter	61	170	<.5	15.8	.08
Beta-gamma radioactivity, pCi/liter	60	630	<14.0	56.8	.28
Background exposure [b]					
mrad/hr	121	.020	.010	.015	17.9

[a] The applicable AEC standards are as follows:

Air (alpha radioactivity)	2 pCi/m³
Air (beta-gamma radioactivity)	1×10^3 pCi/m³
Water (alpha radioactivity)	2×10^4 pCi/liter
Water (beta-gamma radioactivity)	2×10^4 pCi/liter
External beta-gamma radioactivity	0.5 rem/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open-shield Gieger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

levels, measured at the air sampling locations shown in figure 3, are also summarized in table 6. The overall average concentrations and background exposure rates for 1966 and the first half of 1967 are presented in table 7 as percents of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	September 1967
January–June 1967	January 1968

Table 7. Comparison of average concentrations Portsmouth Plant, 1966 and 1967

Type of monitoring	Percent of AEC standard [a]			
	1967			1968
	First half	Second half	Calendar year	Calendar year
Air:				
Alpha radioactivity	5.0	0.23	5.0	1.4
Beta-gamma radioactivity	0.02	.01	0.01	0.02
Water:				
Alpha radioactivity	.09	.08	.08	.09
Beta-gamma radioactivity	.20	.28	.24	.05
Background exposure extrapolated to 3 feet above ground level	[b]16.8	17.9	17.3	17.4

[a] See footnote (a) of table 6.
[b] This value was reported in error as 17.5 for the first half of 1967.

Reported Nuclear Detonations, June 1968

The U.S. Atomic Energy Commission announced a nuclear test or low yield (20 kilotons or less TNT equivalent) was conducted underground at its Nevada Test Site on June 6, 1968.

The U.S. Atomic Energy Commission announced that the United States had twice recorded seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region. On June 12, 1968, the signals were equivalent to those of a nuclear test in low yield range (less than 20 kilotons TNT equivalent) and on June 19, 1968, the United States recorded seismic signals equivalent to those of a nuclear test in the low-intermediate range (20–200 kilotons TNT equivalent.

Announcements were also made by the U.S. Atomic Energy Commission of two nuclear tests of low-intermediate yield (20 to 200 kilotons TNT equivalent) that were conducted underground by the Atomic Energy Commission at its Nevada Test Site on June 15 and June 28, 1968.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1968 302-810/12

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TRITIUM IN SURFACE WATERS OF THE UNITED STATES, 1966. *A. A. Moghissi and C. R. Porter. Radiological Health Data and Reports, Vol. 9,* July 1968, pp. 337–339.

During 1964, a tritium sampling network was established by the Public Health Service to measure the levels and consequently to determine the public health significance of tritium in surface waters of the United States. The analytical procedures used are described. Data for the samples obtained are presented. A means for estimating the radiation dose resulting from tritium in the body is developed. The calculations presented apply only to the areas sampled and cannot necessarily be extrapolated to other locations.

KEYWORDS: population, radiation dose, surface waters, tritium, tritium sampling network.

TRITIATED MOISTURE IN THE ATMOSPHERE SURROUNDING A NUCLEAR FUEL REPROCESSING PLANT. *J. C. Daly, A. V. Manchester, J. J. Gabay,* and *N. I. Sax. Radiological Health Data and Reports, Vol. 9,* July 1968, pp. 341–346.

A new wide-area sampling technique was used to collect more than 700 tritiated moisture samples over a 2-month period from seven sampling legs radiating out from a nuclear fuel reprocessing plant. For the 28 sampling periods studied, the average tritium radioactivity on the sampling leg northwest of the plant exceeded 2,500 pCi/liter, 75 percent of the time and exceeded 10,000 pCi/liter, 39 percent of the time as opposed to ambient levels of $<$2,500 pCi/liter. The highest tritium level recorded was 26,400 pCi/liter. These data are reported not so much for their epidemiologic value as for their value to public health agencies contempating radiological surveillance around nuclear facilities.

KEYWORDS: atmosphere, nuclear facilities, nuclear fuel reprocessing plant, radiological surveillance, tritiated moisture.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check ☐ for this subscription. ($5.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows._____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1968

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $5.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

July 1968

GUIDE FOR AUTHORS

The editorial staff invites reports and technical notes containing information related to radiological health. Proposed reports and notes should contain data and interpretations. All accepted manuscripts are subject to copy editing with approval of the author. The author is responsible for all statements made in his work.

Manuscripts are received with the understanding that other identical manuscripts are not under simultaneous consideration nor have appeared in any other publication.

The mission of *Radiological Health Data and Reports* is stated on the title page. It is suggested that authors read it for orientation of subject matter.

Submission of manuscripts

Send original and one legible copy of the paper, typed double-spaced on 8½ by 11-inch white bond with 1-inch margins.

Submitted manuscripts should be sent to Managing Editor, Radiological Health Data and Reports, National Center for Radiological Health, PHS, Rockville, Md. 20852.

Preparation of manuscripts

The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results, and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature, a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs, whenever possible.

Illustrations: Glossy photographic prints or original illustrations suitable for reproduction which help enhance the understanding of the text should be included with the manuscript. Graphic materials should be of sufficient size so that lettering will be legible after reduction to printed page size (8½ by 6½ inches).

All illustrations should be numbered and each legend should be typed double-spaced on a separate sheet of paper. Legends should be brief and understandable without reference to text. The following information should be typed on a gummed label or adhesive strip and affixed to the back of each illustration: figure number, legend, and title of manuscript or name of senior author.

Tables: Tables should be self-explanatory and should supplement, not duplicate, the text. Each table should be typed on a separate sheet, double-spaced. All tables must be numbered consecutively, beginning with 1, and each must have a title.

Equations: All equations must be typewritten, preferably containing symbols which are defined immediately below the equation. The definition of symbols should include the units of each term. Special symbols, such as Greek letters, may be printed carefully in the proper size, and exponents and subscripts should be clearly positioned. Mathematical notations should be simple, avoiding when feasible, such complexities as fractions with fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements are preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, ^{137}Cs; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number: *e.g.*, strontium-90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

Reprints

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

GUIDE FOR AUTHORS

The editorial staff invites reports and technical notes containing information related to radiological health. Proposed reports and notes should contain data and interpretations. All accepted manuscripts are subject to copy editing with approval of the author. The author is responsible for all statements made in his work.

Manuscripts are received with the understanding that other identical manuscripts are not under simultaneous consideration nor have appeared in any other publication.

The mission of *Radiological Health Data and Reports* is stated on the title page. It is suggested that authors read it for orientation of subject matter.

Submission of manuscripts

Send original and one legible copy of the paper, typed double-spaced on 8½ by 11-inch white bond with 1-inch margins.

Submitted manuscripts should be sent to Managing Editor, Radiological Health Data and Reports, National Center for Radiological Health, PHS, Rockville, Md. 20852.

Preparation of manuscripts

The Government Printing Office style manual is used as a general guide in the preparation of all copy for *Radiological Health Data and Reports*. In addition, *Radiological Health Data and Reports* has developed a "Guide" regarding manuscript preparation which is available upon request. However, for most instances, past issues of *Radiological Health Data and Reports* would serve as a suitable guide in preparing manuscripts.

Titles, authors: Titles should be concise and informative enough to facilitate indexing. Names of authors should appear on the third line below the manuscript title. Affiliation of each author should be given by a brief footnote including titles, professional connections at the time of writing, present affiliation if different, and present address.

Abstracts: Manuscripts should include a 100- to 150-word abstract which is a factual (not descriptive) summary of the work. It should clearly and concisely state the purpose of the investigation, methods, results, and conclusions. Findings that can be stated clearly and simply should be given rather than to state that results were obtained.

A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature, a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs, whenever possible.

Illustrations: Glossy photographic prints or original illustrations suitable for reproduction which help enhance the understanding of the text should be included with the manuscript. Graphic materials should be of sufficient size so that lettering will be legible after reduction to printed page size (8½ by 6½ inches).

All illustrations should be numbered and each legend should be typed double-spaced on a separate sheet of paper. Legends should be brief and understandable without reference to text. The following information should be typed on a gummed label of adhesive strip and affixed to the back of each illustration: figure number, legend, and title of manuscript or name of senior author.

Tables: Tables should be self-explanatory and should supplement, not duplicate, the text. Each table should be typed on a separate sheet, double-spaced. All tables must be numbered consecutively, beginning with 1, and each must have a title.

Equations: All equations must be typewritten, preferably containing symbols which are defined immediately below the equation. The definition of symbols should include the units of each term. Special symbols, such as Greek letters, may be printed carefully in the proper size, and exponents and subscripts should be clearly positioned. Mathematical notations should be simple, avoiding when feasible, such complexities as fractions with fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements are preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, ^{137}Cs; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number; *e.g.*, strontium-90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

Reprints

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON D.C. 20201

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF H.E.W.

If you do not desire to continue receiving this publication, please CHECK HERE ☐; tear off this label and return it to the above address. Your name will then be promptly removed from the appropriate mailing list.